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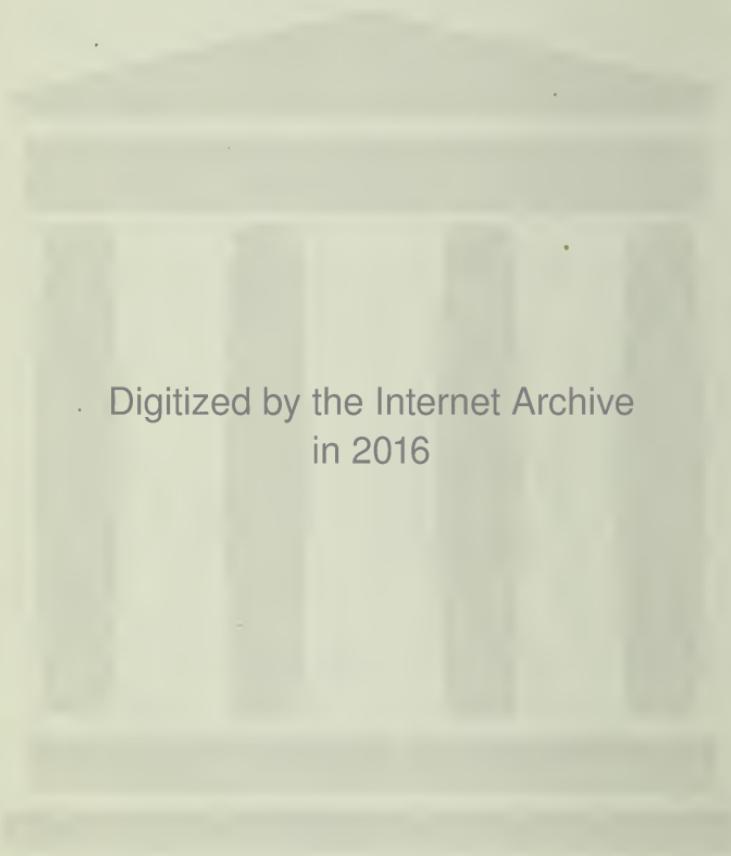
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THE

INTERNATIONAL PHYTOGEOGRAPHIC EXCURSION (I.P.E.)
IN AMERICA, 1913.

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THE INTERNATIONAL
PHYTOGEOGRAPHIC EXCURSION (I.P.E.)
IN AMERICA, 1913.

BY

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INTERNATIONAL PHYTOGEOGRAPHIC EXCURSION
(I.P.E.) IN AMERICA, 1913.

ONE of the most pleasing results of the International Phyto-geographic Excursion in the British Isles organised by the British Vegetation Committee in 1911, was the enthusiasm with which the visitors from abroad decided to go and do likewise. The first outcome of these resolves has been the magnificent American tour of 1913, lasting two months (August and September), and attended by ten Europeans—Dr. H. Brockmann-Jerosch, Frau Dr. Marie Brockmann-Jerosch (Zürich), Professor Engler (Berlin), Dr. Ove Paulsen (Copenhagen), Dr. Edward Rübel (Zürich), Professor C. Schröter (Zürich), Dr. T. J. Stomps (Amsterdam), Mr. A. G. Tansley, Mrs. Tansley (Cambridge), Professor C. von Tubeuf (Munich).

The tour was arranged by Professor Henry C. Cowles (Chicago) and Professor F. E. Clements (Minneapolis), but owing to various circumstances the great bulk of the work of organisation rested on the shoulders of Professor Cowles, to whom the deepest gratitude of all the members of the party is due, not only for the completeness and perfection of the arrangements, but also for his unfailing kindness, good humour and self-sacrifice throughout the trip. Without these qualities in a leader, indeed, the best organised tour might well turn out unsatisfactory and even unpleasant.

Professor Cowles had two able assistants, Mr. George D. Fuller (Chicago), and Dr. George E. Nichols (New Haven), one of whom attended to the railroad tickets, and the other to the baggage of the party, but they by no means confined themselves to these very necessary tasks. Both were of the greatest assistance to the European visitors in the many unfamiliar situations incidental to American travelling, and both most substantially helped Professor Cowles to make the journey a profitable and pleasant one. Both Mr. Fuller and Dr. Nichols also took numerous photographs throughout the tour; and these will be available for members of the party, and will no doubt form a valuable record of the trip.

Besides the above-mentioned leaders, many American botanists joined the party for shorter periods; and indeed one of the pleasantest features of the tour lay in the numerous opportunities thus afforded to the visitors from abroad of making the acquaintance of their American *confrères*.

The arrangements of the organisers included the provision for members of the party of a pamphlet detailing the general arrangements of the tour (and incidentally furnishing a most useful guide to American travelling in general); as well as of a series of six sectional excursion programmes with full itineraries of each section, and excellent descriptions of the scenery and vegetation passed through by train or visited by the party.

The following notes do not, of course, profess to be in any way a complete record of the excursion; such a record would require indeed a considerable volume. They merely attempt to present an outline of the tour and such of the impressions of the present writer as may be conveniently set down in this place.

Most of the members of the party arrived in New York during the closing days of July, and made trips to the interesting "edaphic prairie" of Hempstead Plains in Long Island, and to the pine-barrens and salt marshes of New Jersey. The writer joined the party some days later at Chicago, and is thus unable to speak from personal experience of these excursions, but it may be stated that the New Jersey pine-barrens are of special interest to the European botanist, because they have much in common with European heathland. Dominated by *Pinus rigida*, with which are associated several species of more or less dwarf and scrubby oaks, forming a sparse and open woodland, the sandy soil is largely covered with a shallow dry peaty humus formed by *Cladonia*, and sometimes by species of *Polytrichum*. Species of *Vaccinium* and the closely-allied *Gaylussacia* are also characteristic. On the whole, as in the case of the European heaths, the formation is, floristically, rather poor. In the depressions between the sand-ridges are "cedar-swamps" dominated by *Chamæcyparis thyoides*, in which occur *Sarracenia purpurea* and *Schizæa pusilla*. Professor Harshberger, of Philadelphia, was the principal leader.

In New York the party visited the unique Brooklyn Botanic Garden, the Botanical Department of Columbia University, under the charge of Professor R. A. Harper, and the New York Botanical Garden in Bronx Park, which bids fair to become one of the leading botanic gardens of the world. The Garden contains a tract of

primitive eastern deciduous woodland, with a fine grove of hemlock spruce (*Tsuga canadensis*); and the beautiful valley of the stream which traverses the Garden is skilfully utilised for the arrangement of the herbaceous beds. The water-loving plants are on the margin of the stream, and the xerophilous on the dry summit of the ridge close to some fine glaciated rocks, while plants of intermediate water preferences occupy the slopes between. The taxonomic affinities of the various families are brought out by the arrangement of the beds along the valley. Dr. Britton, the accomplished Director of the Gardens, and Mrs. Britton, so well known by their genial hospitality to botanists visiting New York, and Professor Harper, entertained the members of the party.

Leaving New York on the night of Wednesday, July 30th, the party made a stop at Niagara Falls on Thursday, and arrived at Chicago on the morning of Friday, August 1st. The international party was received by the staff of the well-known Botanical Department of the University, in the Botany Building, and afterwards entertained to lunch at the Quadrangle Club. Professor John M. Coulter, head of the Department, gave a short address of welcome, and then Professor Cowles delivered a short but exceedingly useful lecture on the physiographic and geological features of the Chicago region, indicating their relations to the vegetation and flora. The writer was amused by a remark made to him by an American botanist to the effect that whatever part of the United States one visited one was always told by the local botanist that this was a specially interesting region, because it was the meeting-point of two floras, the eastern and the western—or perhaps the northern and the southern—the obvious inference being that the conception of a “northern” or of a “western” flora gradually shifted as one moved south or east. There can be no doubt, however, as Professor Cowles insisted, that the Chicago region is, in a very real sense, the meeting-place of a northern and southern flora, and of an eastern and western vegetation. This means, of course, that there are actually a large number of species characteristic of the north or of the south which are found intermingled in this region, and that in Illinois and neighbouring States, the great eastern deciduous forest begins to give way to prairie.

One of the greatest attractions of the Chicago neighbourhood to the ecologist is, of course, the magnificent series of sand-dunes on the southern and eastern shores of Lake Michigan, and a large

proportion of the week spent at Chicago was devoted to the vegetation of these dunes, already well-known to students of ecology from Professor Cowles' paper in the *Botanical Gazette* for 1899. An exceedingly useful pamphlet on "The Vegetation of the Chicago Region" was distributed to the members of the party, including a summary of the plant-associations with lists of species.

CHICAGO SAND DUNES.

The succession of plant-associations on the sand-dunes of the southern shore is very complete, well-marked and constant, leading from a beach association—very poor floristically like the maritime sandy beach associations of temperate regions in general, and including *Cakile* and such forms as *Corispermum hyssopifolium*, *Euphorbia polygonifolia*, *Cirsium Pitcheri*—through a fore-dune association characterized by sand grasses such as *Ammophila* and *Calamovilfa*, and by willows and sand-cherry, to a cottonwood association characterized by *Populus deltoides*, and occupying many of the large mobile dunes. From this point onwards the succession changes its character, owing to the protection from wind afforded on the landward side of the high mobile dunes; and the vegetation undergoes rapid stabilization and a subsequent succession. According to one American member of the party a sand prairie grass association in which the bunch grass (*Andropogon scoparius*) figures, can often be distinguished as the initial phase of this succession: the prairie grasses are quickly succeeded by pines (*Pinus strobus*—largely cut out on account of the value of its timber—and *Pinus Banksiana*, the dominant species), with which *Juniperus virginiana* and *Thuja occidentalis* are mingled. This pine-association has a very characteristic undergrowth of *Juniperus communis*, *Arctostaphylos Uva-ursi*, *Pyrola* spp., etc. Under the shade of this vegetation humus begins to develop in quantity for the first time. The pine-association soon begins to be invaded by the black oak (*Quercus velutina*), and a crowd of the less sciaphilous woodland shrubs and herbs. The pines are rapidly suppressed, and the typical black oakwood, often open, but in many places with a closed canopy, is established. This association forms a zone at least two or three miles wide in some places.

Here and there in the hollows are small lakes and marshes representing detached portions of "Lake Chicago" which have not been overwhelmed by the dunes, and showing all stages of succession from open water, through reed swamp, to an association of willows, etc., with other swamp-loving trees. Whether these areas

ever become oakwood unless they are actually overwhelmed by sand is doubtful.

The black oakwood is often invaded by other species of oak, such as *Quercus alba* and *Q. rubra*, and thus passes to a mixed oakwood association with *Tilia americana*, etc., and many more shade-loving forms. Eventually this may be replaced, as is admirably seen at Sawyer, Michigan, by the typical shade trees of the north-eastern United States, dominated by the beech (*Fagus grandifolia*) and the sugar maple (*Acer saccharum*), with scattered examples or local groves of *Tsuga canadensis*, and such characteristic trees and shrubs as *Liriodendron tulipifera*, the papaw (*Asimina triloba*), the witch hazel (*Hamamelis virginica*) and the spice bush (*Benzoin aestivale*), etc., though some of these may occur somewhat earlier in the succession. The beech-maple forest shelters a typical shade-loving vegetation, with the beautiful and characteristic shade fern *Adiantum pedatum*, *Polystichum acrostichoides*, *Aspidium marginale* and *A. spinulosum*, and numerous angiospermous shade-herbs. There can be no doubt of the essential identity of this climax association of the sand-dune succession with the typical climax beech-maple forest of the neighbourhood as developed on clay soils.

Such a forest on glacial clay was visited near Three Oaks, Michigan, and though some of the species differ from those of the beech-maple forest on old sand-dunes, the essential identity of the vegetation in the two cases cannot be questioned.

MR. WARREN'S BEECH-MAPLE FOREST.

This beech-maple forest on clay is a magnificent specimen of virgin deciduous forest. The beeches and maples are about equal in numbers, and their tall finely-shaped trunks tower to a great height. One large maple measures $15\frac{3}{4}$ feet in circumference 2 feet from the ground. The shade cast is dense, and the evaporating power of the air very low. There is a typical shade ground vegetation with abundant ferns and many humus plants. The free rejuvenation of the dominant trees is a marked feature, a large proportion of the woody undergrowth being formed of young beeches and maples. In some places there is, I think, some evidence of differentiation of the ground vegetation by the local occurrence of more sandy soil. Round the shallow pools left in old "oxbows" of the river, such trees as *Platanus occidentalis* and the "soft" maple (*Acer saccharum*) occur.

This fragment of beech-maple forest is one of the few remnants of the magnificent deciduous forest that once covered nearly

the whole of the north-eastern United States. Dr. Nichols informed us that the last remaining fragment in Connecticut was destroyed a year or two ago. The Three Oaks forest owes its preservation to the fine spirit of its owner, Mr. Warren, of Three Oaks, a feather-bone manufacturer. Mr. Warren originally bought the area for lumbering purposes, but was so greatly impressed by its beauty and interest that he has preserved it practically untouched, and is willing, we understand, to hand it over to a public authority, if guarantees can be obtained for its proper maintenance and preservation—a somewhat difficult matter. The members of the international party were delighted at having the opportunity of expressing to Mr. Warren's sons—by whom they were taken to and from the forest in automobiles, and afterwards most charmingly entertained at lunch at the Lakeside Club—their sense of the great debt of gratitude which not only botanists, but all lovers of untouched nature owe to Mr. Warren senior in this matter. The imagination and insight into the deeper æsthetic and indeed spiritual needs of the community shown by Mr. Warren are at present all too rare among the business men of any country. But we may confidently expect a time to come when education and greater leisure has raised the general demand for and appreciation of the glories of unspoiled nature. Future generations will be slow to forgive us for the wholesale and often wanton destruction that goes on at present almost unchecked by any general feeling that it is an antisocial crime, and quick to applaud the actions and to reverence the memories of those who have done something to preserve their heritage of natural beauty. No one but a fanatic, indeed, entirely out of touch with the realities of life, would expect to hamper the economic development of a great country, which necessarily involves the replacement of forest and prairie by corn-fields and factories. But here and there tracts of original untouched nature can and should be preserved for the enjoyment and use of our successors, without in any way checking general and inevitable economic development. This is work which ought to be undertaken by the community, and indeed the great national and the smaller State "parks" of the west—three of which were visited by the international party—are a sign that America is awake to her responsibilities to the future in this matter. In the east the work of preserving unspoiled areas is more difficult, and there is less opportunity for it because comparatively little original vegetation is left. All honour, then, to those few who have the

insight and the generous spirit to subordinate motives of immediate material profit to higher and deeper considerations. Comparatively few may be found as yet to pay this honour, but those few will become many as time goes on, and the general level of appreciation of the permanent and underlying factors of human life in its widest sense is gradually, as it will inevitably, be raised to a higher and higher level.

EFFECT OF MOVING SAND-DUNES ON FOREST VEGETATION.

All the stages of the sand-dune succession subsequent to the cottonwood stage are liable to be overwhelmed by moving masses of sand, 100 feet or so high, and the sequence of events that occurs when the later forest stages are thus invaded is most interesting. If the advancing face is moving at a comparatively slow rate, many of the trees and shrubs of the forest are not killed by the sand, but are able to grow up *pari passu* with the advance, and keep leafy shoots always above the surface, *e.g.*, species of *Rhus*, *Tilia americana*, *Prunus serotina*, *Vitis vulpina*, etc. This power depends upon the capacity to strike adventitious roots into the layer of damp sand which is found a few inches from the surface throughout the year. It is this capacity which enables the cottonwood (*Populus deltoides*) to dominate the less rapidly moving dunes. The seeds of this tree can only germinate in the very damp soil of the shallow depressions near the beach where the bottom water nearly reaches the surface, or in places with a similar soil-water content on the edges of pools. The seedlings can, however, hold their own by the rapid upgrowth of their shoots through successive layers of invading sand, into which, as soon as it becomes moist, adventitious roots are sent (provided, of course, that the onset is not too rapid); and thus many of the lower but still considerable dunes near the sea are loosely covered with flourishing cottonwood trees which started life at a level sometimes scores of feet below the existing surface. Where wind erosion has subsequently destroyed part of such a dune the eroded face shows the old stems and adventitious roots of the cottonwood at all levels.

When a large moving dune invades a forest belonging to one of the later stages of the dune succession, some of the trees, *e.g.*, *Pinus Banksiana* and *P. Strobis* are killed very soon, and neither the oaks nor the sugar-maple (*Acer saccharum*) can survive very long; but the trees and shrubs mentioned above maintain themselves by keeping pace with the rising sand. Accordingly we have

the strange spectacle of the top of such a dune dotted over with perfectly healthy and vigorous examples of these trees and shrubs, representing the rejuvenated tops of individual members of a closed forest association buried many feet below the existing surface. None of these trees can, however, survive subsequent removal of the sand by wind.

EROSION OF DUNES.

Besides the constructive phases of the sand dune succession outlined above, the international party visited an example (at Michigan City) of erosion of forested dunes by wave action. Here the advance of the lake, by undercutting the base of the sloping sand cliff, was causing the sand to slip down the slope from the eroding edge of the forest floor, sometimes slowly and gradually, sometimes in considerable masses. Here and there large masses of sand holding the roots of great forest trees had slipped half-way down the sloping cliff, and the trees were still alive and in the erect position. In other cases, of course, the trees had collapsed altogether, and lay prostrate upon or at the base of the cliff. Parallel cases of the erosion of clay cliffs with the gradual destruction of the forest occupying the top of the cliff were observed at Lake Bluff, north of Chicago.

At this locality, too, a small sand-dune area with a somewhat different vegetation from that characterising the dunes on the southern shore of the lake was visited. Here the front of the dunes was occupied by a *Calamovilfa* association, closely resembling the *Ammophila* associations of European maritime dunes. Behind this was a belt of *Populus balsamifera*, which replaces *P. deltoides* here and there on the southern dunes and increases towards the north, and then came a narrow but very well-defined belt of *Juniperus horizontalis*, a very characteristic shrub, with horizontally-growing branches, associated with *Juniperus communis* (with its typical form and also a form close to *J. nana*) and *Arctostaphylos Uva-ursi*, together with a few examples of *Pinus Banksiana*. At the back of the dunes, where these abutted upon the clay cliffs, the oak forest of the cliffs had sent a fringe of deciduous trees, shrubs and woodland plants on to the sand. The shore erosion of the lake cut obliquely across the face of this little dune area; at the south end embryonic dunes were still forming, and following the shore northwards the erosion had reached successively older stages of the dune vegetation till finally it cut into the clay cliffs themselves.

OTHER TYPES OF FOREST.

In this neighbourhood the oak-hickory forest (*Quercus alba*, *rubra*, *velutina*, *macrocarpa*, *Carya ovata*, *Juglans* spp., etc.) on the clay cliffs was visited—quite a different type from the beech-maple climax forest already described. Here, however, the oak-hickory forest is regarded as the climax forest, the climatic region in which the beech-maple forest is the climax type having now been left. The trees on these clay cliffs are never very large or lofty, though the forest is mature.

The V-shaped ravines cut by small streams through these clay cliffs present an interesting and decidedly more hygrophytic type of vegetation, including such trees as *Acer saccharum*, *Tilia americana*, *Quercus rubra*, *Ulmus americana*; and such herbaceous plants as the handsome *Aralia racemosa*, *A. nudicaulis*, *Sanicula marylandica*, *Hepatica acutiloba*, *Thalictrum dioicum*, *Solidago latifolia*. This ravine forest is closely allied to the flood-plain and to the eastern climax types.

Another type of forest visited by the party during their stay at Chicago was the flood-plain forest developed along the damp river bottoms. This is a very characteristic type and quite rich floristically. *Salix nigra*, *S. amygdaloidea* and *Populus deltoidea* frequently fringe the river itself, and in the forest behind *Ulmus americana*, *Acer saccharum* and *Platanus occidentalis* are very characteristic, associated with *Fraxinus americana* and *F. nigra*, *Acer Negundo*, *Juglans* spp. etc. On the ground *Osmorrhiza brevistylis*, *Cryptotaenia canadensis*, *Convolvulus sepium*, *Aralia nudicaulis*, *Sicyos angulatus*, *Campanula americana* and many other species occur.

This river-bottom type of forest is specially interesting because it is the type which extends, though greatly impoverished floristically, far to the westward into the region of climatic prairie, and indeed along the larger rivers right through the Great Plains region to the base of the Rocky Mountains. *Pseudera (Ampelopsis) quinquefolia*, the "Virginia creeper," is ubiquitous in all these types of deciduous forest.

An interesting tamarack (*Larix laricina*) swamp, developed just behind the dunes, on the edge of an old river valley was visited on August 3rd. Here a succession can be traced from open water (perhaps an old hole in the river-bed that remained as a pond after the river was obliterated) of which practically nothing remains, through reed-swamp and sedge to tamarack wood. The centre of

the swamp is now mostly occupied by an association of various species of *Carex*, including *C. filiformis* and *C. Pseudocyperus*, which are dominant. These are developed on a floating layer of peat through which rise numerous shoots of *Scirpus lacustris* and *Typha latifolia*, with here and there *Phragmites communis* and *Cladium mariscoides*, relicts of the former reed-swamp. *Lastrea Thelypteris* is very abundant on the peat, which has many of the characteristics of English fen. In places, however, bog plants such as *Sarracenia*, *Drosera* and others occur. A phase of shrubs (*Salix caudata*, *Rhus veruix*, *Betula pumila*, *Rhamnus alnifolia*, etc.) leads on to the close canopy tamarack wood of *Larix laricina* and *Betula lutea* with *Acer rubrum*, *Nyssa sylvatica*, etc., and on the ground *Osmunda cinnamomea*, *O. regalis*, *Mitchella repens*, *Coptis trifolia*, *Trientalis americana*, etc.

This succession appeared to the European botanists to be essentially of the "Niedermoer" or fen type, with local tendencies only to develop a "Hochmoor" vegetation, as was seen in a neighbouring hollow dominated by *Chamaedaphne*. From descriptions however it would appear that some if not all of the more northern tamarack swamps arise from a "Hochmoor" succession.

CHICAGO PRAIRIE.

The Chicago region, as has been said, is naturally a region of mixed forest and prairie. To the east the eastern climax (beech-maple) type of forest predominated: to the west the prairie areas gradually increase, and the forest areas (oak-hickory type) decrease. The prairie shows several more or less distinct types, such as low prairie, blacksoil prairie, sand prairie and so on. Low prairie is clearly, in this region at least, a natural succession from lake and marsh or fen. Good transitional stages between fen and low prairie may be observed close to Chicago in the vicinity of Wolf Lake, and low prairie still exists within the city limits at Chicago Lawn. This contains, however, a good many species said to be typical of high prairie. Thus it is largely dominated by *Agrostis* with the ubiquitous *Poa pratensis* (called in America "Kentucky blue-grass") *Hordeum jubatum*, and *Elymus canadensis*. Among the species which clearly show the origin from fen and which are familiar to the European botanist are *Lathyrus palustris* and *Stachys palustris*; while *Spartina cynosuroides*, *Calamagrostis canadensis* and *Muhlenbergia racemosa* are low prairie grasses. Mixed with these are numerous Composites: *Liatris spicata*, *Aster multiflorus*, *Solidago rigida* and *canadensis*, *Erigeron ramosus*,

Rudbeckia hirta, *Lepachys pinnata*, *Helianthus strumosus*, etc., etc. Among these are *Silphium laciniatum* (the well-known compass-plant), *S. terebinthinaceum* (prairie-dock), *S. integrifolium* (rosin-weed) and *Cacalia tuberosa* (Indian plantain) with their stiff conspicuous leaves. Other common high prairie species are *Potentilla canadensis*, the beautiful *Phlox pilosa* and *glaberrima*, *Petalostemnum purpureum* and *candidum* (prairie clovers) and *Lobelia spicata*.

The prairies show several seasonal phases marked by the showy flowers of different abundant species which mature at different periods of the summer and early autumn.

The Chicago prairie is certainly a relatively stable plant-community, and some local botanists declare that its edges have shown no tendency to be invaded by forest for the last half-century. Professor Cowles, however, considers that on the whole it is probably to be regarded as a stage antecedent to forest. The Chicago region is physiographically very young, the low-lying land near the city and to the south-east having been comparatively recently exposed by the retirement of "Lake Chicago," the more extensive predecessor of Lake Michigan: and on general grounds it may well be that the succession of vegetation over the region as a whole has not yet reached its "climax type." In some places marsh or fen passes not into prairie but directly into forest. The factors which determine these different fates are not certain, but it is quite likely that they are due to the historical accident of the invasion of forest vegetation in one place and prairie vegetation in another, according to local proximity of the two parent types. When the prairie vegetation obtains a good hold of the ground, it would naturally greatly delay, even if it did not wholly prevent the invasion of forest.

START FOR THE WEST.

Taking leave of our kind hosts of Chicago, we left the city westward bound on the evening of Friday, August 8th, travelling straight through to Lincoln, Nebraska, where we arrived on the following morning. Through Illinois the characteristic oak-woods of the rising ground, largely dominated by *Quercus macrocarpa*, alternate with prairie in the depressions with black soil often derived from fen. The plain, however, is largely cultivated (maize, wheat, etc.) and the woods are mostly passing into a degenerate condition owing to their use as pasture grounds for cattle. The Mississippi was crossed after nightfall, and throughout the night we traversed the state of Iowa, a typical prairie state, now almost entirely under

cultivation. In the daytime the journey across Iowa, at least by this route (the Burlington), is exceedingly monotonous. The gently rolling country is covered with a continuous succession of maize and wheatfields, with occasional pastured oak-wood on the higher ground, and no glimpse of untouched prairie can be seen. The oakwoods become rarer as the western boundary of the state, the Missouri river, is approached. The train crosses the river and runs northward along the west bank for some distance before Omaha, the largest city in Nebraska, is reached, and good stages of the development of flood plain-forest from sandbanks can be observed. The bluffs overlooking the Missouri, composed of loess, bear oak-wood.

On leaving Omaha, the plain, originally prairie, is now closely cultivated. The Platte river, one of the streams that come right through to the Missouri from the Rocky Mountains, is crossed and shows a narrow belt of fringing "river bottom" woodland.

At Lincoln the party was met by the veteran Professor Bessey, who had charge of the arrangements during the comparatively few hours we spent in that city. Thanks to the care with which Professor Bessey had planned the trip and to the generosity of the Commercial Club, which not only provided the whole party with automobiles, but also with an excellent luncheon at the clubhouse, we were able to use our limited time to the best advantage. We were also honoured by the presence of the Governor of the State and the Chancellor of the University of Nebraska, who were not only present at the luncheon but also accompanied the party on the automobile trip. The day was one of the hottest in the year, a shade temperature of 108° F. being recorded by the meteorological station in the afternoon. Thanks, however, to the automobiles and to provision of a shaded room at the club for resting during part of the afternoon, but little discomfort—except indeed from dust—was experienced.

LINCOLN PRAIRIE AND PLANTATIONS.

During the afternoon, several areas of rolling high prairie were visited, and these presented a striking contrast with the "low prairie" seen at Chicago. The high prairie grassland was dominated mainly by *Stipa spartea*; *Panicum scoparium* was locally dominant, and *Spartina michauxiana* on the lower-lying prairies. *Kæleria cristata* (agg.)—an extremely abundant grass throughout temperate North America—was also in evidence. Of conspicuous

dicotyledons forming the typical prairie "societies" of Clements, there are the Leguminous species *Psoralea tenuiflora* and *esculenta*, *Amorpha canescens*, *Petalostemnum purpureum*, *P. candidum*; and the Composites *Aster multiflorus*, *Solidago rigida*, *S. serotina* and *Vernonia fasciculata*, the last six species common to the typical climatic prairies of Lincoln and the far distant local prairies at Chicago Lawn. *Echinacea angustifolia*, the "Niggerhead," with its strongly convex almost black disc, is an abundant and conspicuous species.

The river-bottom forest fringing the streams is composed of *Ulmus americana*, *Acer saccharinum*, *A. Negundo*, *Quercus macrocarpa*, *Fraxinus lanceolata*, *Celtis occidentalis*, *Juglans nigra*, etc., with *Symporicarpus racemosus*, *Ribes oxyacanthoides*, *Smilax hispida*, *Rhus Toxicodendron*, *Vitis vulpina*, etc., representing shrubs and lianes. Unfortunately, the examples of this association near Lincoln have all been pastured and the natural boundary between forest and prairie entirely destroyed. It is stated, however, from several different sources, that since the cessation of prairie fires, the forest steadily advances on the prairie where it has the chance *i.e.*, where the tree seedlings are not eaten down by cattle. This fact, however, scarcely justifies the view taken by one European member of the party, that the whole of the prairie is artificial and that its soil has previously borne forest! It is true that trees will grow, and grow well, when plantations are made on the prairie. We visited two plantations, one forty-four years old, composed of the western cottonwood *Populus Sargenti*, in which the trees were thirty to thirty-five feet high and in a flourishing condition. The soil of this plantation having been much trampled, bore mainly a grass vegetation, though three or four woodland plants had colonised it. But in the case of another plantation, the "Rogers woods," which was planted on the high prairie about thirty years ago, mainly with *Juglans nigra* and *Acer Negundo*, with some *Acer saccharinum*, *Ulmus americana*, *U. fulva*, *Fraxinus lanceolata*, and *Toxylon pomiferum*, the existing state of things is very striking. The two first-mentioned species are reproducing themselves freely, as also is *Ulmus americana*: *U. fulva* and *Fraxinus lanceolata* to a less extent. Seventeen other trees, shrubs and lianes have appeared, of which the great majority are native woodland forms; and at least thirty-six herbaceous species are now present, including ten woodland species. These data were very kindly collected for me by Professor Bessey, and afford a most interesting piece of

information on the subject of the assimilation of plantations on non-forest soil to natural woodland types. To argue from facts of the kind mentioned to the startling conclusion that the whole of the existing prairies were once forest-covered is, however, scarcely legitimate.

In the near neighbourhood of Lincoln there are areas impregnated with salt, and these bear a specialised vegetation, which, according to Professor Clements, shows a well-marked succession from saline and brackish aquatic forms through *Salicornia* communities to communities of *Atriplex*, *Corispermum*, *Dondia* (*Suaeda*) and *Salsola*. On the less salty portions of this basin, the party met several of the typical "shortgrass" plants of the Great Plains for the first time, such as *Bouteloua*, *Bulbilis* and *Grindelia*. These plants, presumably unable to endure the competition of the typical prairie species, colonise the edges of the saline areas, where many of the prairie plants cannot get enough water, just as they cannot in the climatically drier Great Plains.

In the late afternoon the party had the pleasure of visiting the Botanical Department of the University of Nebraska, and of listening to a lantern lecture by Dr. Raymond Pool on the sand-hill vegetation in the north of the state, where there is an immense development of inland dunes. Dr. Pool, scarcely recovered from a very severe illness, laid the party under a deep obligation by his excellent account of this region, of which he has made a thorough study. A small example of the same type of vegetation was visited on the following day near Yuma, Colorado.

LINCOLN TO AKRON.

At six o'clock the party left Lincoln on their westward journey, delighted with their reception at the capital of Nebraska. The journey to Akron, Colorado, the next stopping-place, a distance of a little over 350 miles in a straight line, was made during the night, so that the transition between the Prairies and the Great Plains was not seen. As one travels westward the altitude gradually rises, from 1,148 feet at Lincoln to 4,650 feet at Akron and 5,183 feet at Denver, 15 or 20 miles from the foothills of the Rocky Mountains. The rainfall gradually decreases, from 27½ inches at Lincoln to 16 inches at Akron and 14 inches at Denver. These figures, however, give little idea of the actual aridity to the inhabitant of a country with a maritime climate like that of North-Western Europe, where the evaporation rate is very much lower. Most of the country near

the railroad during the first part of the journey is cultivated, the chief crops being wheat "corn" (maize), sorghum and alfalfa (lucerne), and very little prairie vegetation is seen. As the Great Plains region is entered the cultivation becomes occasional only, and the country is covered with the typical "short-grass" vegetation, having a totally different aspect from typical prairie. This is a grazing country, and "dry farming" unless with a considerable capital is a very precarious means of livelihood. The shortgrass vegetation is broken here and there by sand-hills which bear (strangely as it will seem to a European) a decidedly more luxuriant vegetation, akin to the prairie type, and largely dominated by bunch-grass (*Andropogon scoparius*). The small streams crossed are dry for a considerable part of the year and as one passes westwards into the Great Plains the fringing woodland gradually thins out and disappears, though the larger rivers which never dry up still retain it.

THE GREAT PLAINS REGION—AKRON, COLORADO

Akron is a little town, very typical of the newer "middle west," lying in the heart of the Great Plains about 100 miles from the eastern foothills of the Rocky Mountains. About four miles from the town is the experiment station of the United States Department of Agriculture—one of the most important of the federal agricultural experiment stations, and largely devoted to the interests of the dry-farming and stock-raising carried on in this district.

At this station members of the staff of the Bureau of Plant Industry of the federal department have for some years been carrying on a series of very important large scale experiments on the water requirements of plants—particularly of the commonly cultivated crop-plants—wheat, alfalfa, sorghum, corn, etc., and of the native plants also. An account of the first series of these experiments by Drs. Briggs and Shantz has just been published (Bulletin 284 of the Bureau of Plant Industry, 1913). In 1911 Dr. Shantz published a Bulletin in the same series (No. 201) entitled "Natural Vegetation as an Indicator of the Capabilities of Land for crop-production in the Great Plains area," and giving an excellent account of the natural vegetation of this neighbourhood and of its relation to the crops.

The international party arrived at Akron early on the morning of August 10th, and was joined by Professor and Mrs. Clements,

Two days were spent in the neighbourhood. The members of the party not only had the opportunity of studying the native vegetation under the guidance of Mr. T. H. Kearney and Dr. Shantz, but were also able to inspect the experiments above mentioned under the guidance of Drs. Briggs and Shantz, and to obtain a first-hand idea of the methods of work. A particularly fine set of automatically recording instruments for measuring meteorological and other physical factors is installed at the station. Automobiles were most kindly lent by the principal citizens of Akron, and these made it possible to visit in a day the sand-hill region near Yuma, about thirty miles from Akron, as well as various typical associations of the Great Plains passed *en route*.

The Great Plains region covers an enormous area of country, extending northwards into Canada and southwards as far as Texas, with strikingly little change in the essential character of the country and of the vegetation. In physiographic character the Great Plains are very uniform, consisting of flat or gently rolling grassland on a clayey or loamy soil. Over considerable areas there are large deposits of sand, and these form sand-dunes in all stages of fixation by vegetation, and of rejuvenescence by the formation of blow-outs, and bear a distinctly different vegetation from the finer grained more compact soil of the rest of the area. The region is intersected by stream-courses, most of which are dry "sand-draws" for most of the year. Only the larger rivers, such as the Platte, the Republican and the Arkansas, rising in the Rocky Mountains or the foothills and running through to the Missouri-Mississippi system, maintain their streams at all times.

The main area of the plains is covered by the "short grass" association, dominated by the grama-grass (*Bouteloua oligostachya*) and the Buffalo-grass (*Bulbilis* or *Buchloë dactyloides*). Under the natural conditions these grasses do not attain a height of more than 2 or 3 inches above the soil. They form a fairly close sod with little bare soil showing between the plants. Associated are such plants as *Festuca octoflora*, *Plantago Purshii*, *Salsola pestifer*, *Munroa squarrosa* (annual), and *Schedonnardus paniculatus*, *Opuntia polyacantha*, *O. fragilis*, *Mamillaria vivipara*, *Malvastum coccineum*, *Grindelia squarrosa*, *Ptiloria pauciflora*, *Gaura coccinea*, *Aragallus Lambertii*, etc. (perennial). In 1913 *Grindelia squarrosa* occurred in enormous quantity in the Akron district, its erect bright-green shoots, a foot or more high, forming a striking contrast to the grey of the short grasses. After rain the short grasses turn rapidly

green—only to revert to the grey colour of their dry state in the succeeding drought.

The competition for water in the upper layers of the loamy soil is very severe. The short grasses by their shallow rooting habit are well adapted to utilise the rain directly it falls, and owing to this fact and to the intense evaporation and the slow percolation through the heavy fine-grained soil, very little water ever reaches lower levels. Soil boring clearly shows that while a certain amount of moisture is retained during drought in the surface-layers of soil, the underlying layers are extremely dry and the water they hold is unavailable to plants. The factor of the capillary rise of water does not enter into the conditions. Local irregularities in the compactness of the soil, however, cause considerable differences in the water-relation, and where the soil is looser percolation increases, deeper rooting plants flourish, and partly or completely exclude the short grasses. These water relations are no doubt the main explanation of the absence of trees in the Great Plains. When the soil is broken and trees are planted they make healthy growth though they do not attain any considerable size. It is certainly not true that the dryness of the air excludes tree-growth in this region. If the soil is broken by ploughing and left fallow the ground is first colonised by an open association of ruderals including *Amaranthus græcizans*, *Salsola pestifer*, *Festuca octoflora*, *Plantago Purshii*, *Munroa squarrosa*, *Chenopodium* spp., etc. This gradually gives place to an association in which the yellow flowered composite *Gutierrezia sarothræ* and the grey *Artemisia frigida* may share dominance. The former species is on the whole more southern and the latter more northern in distribution, but in the central region of the plains the two are generally associated, and in this association also occur *Bouteloua oligostachya*, *B. curtipendula*, *Mentzelia nuda*, *Petalostemum purpureum*, *Paronychia jamesii*, *Eriogonum effusum*, etc.

The *Artemisia-Gutierrezia* association gradually passes over, by the increasing dominance of the short grasses, into the typical climax or "chief" association of the formation. The whole succession from fallowing back to short-grass takes from twenty to fifty years to complete. Parallel with this succession following ploughing a natural succession may be traced where areas of disintegrating rock occur. Here a lichen association takes the place of the weed association of fallow arable, and gradually passes over into the *Artemisia-Gutierrezia* association, which in this case is richer in associated species. The remainder of the succession is

essentially the same, though in some cases the *Artemisia-Gutierrezia* association may maintain itself against the short-grass invasion for a long time. Locally, particularly on "adobe" soils, the wheat-grass association, dominated by *Agropyrum Smithii*, occurs. This association is much more widespread further to the north, for instance in the Dakotas.

On the areas of sandy soil there is, as has been said, quite a distinct vegetation which is much more luxuriant than the short-grass vegetation. This is owing to the fact that the rain-water percolates through sand much more quickly, and the air-dry surface-layer acts as a dry mulch, checking evaporation from the deeper layers. The plants are deeper-rooting and have a larger available water-supply. The typical climax vegetation is dominated by the tall bunch grass (*Andropogon scoparius*)—a dry prairie-grass which has been already noticed as occurring on the Lake Michigan sand-dunes. Associated with the bunch-grass are such species as *Bouteloua hirsuta*, *Andropogon Hallii*, *Calamovilfa longifolia*, *Panicum virgatum*, *Psoralea tenuiflora*. *Eriogonum annuum* is scattered thickly through the association in places.

The sand-hill succession is started by a "blow-out" which provides an area of bare sand. This is colonised by *Muhlenbergia pungens*, *Redfieldia flexuosa*, *Psoralea lanceolata*, and *Petalostemum villosum*, forming an open association; and is followed by the sand-hills mixed association (Shantz), a very variable "intermediate" association characterised by a large number of species, including *Yucca glauca*, *Bouteloua curtipendula*, *Andropogon scoparius*, *Artemisia canadensis*, *Ipomoea leptophylla*, *Thelesperma gracile*, *Sorghastrum nutans*, *Chrysopsis villosa*, *Amorpha canescens*, etc.: and this in turn by the bunch grass association.

If the bunch grass association is broken by ploughing and left alone ruderals at first colonise the ground and are followed by the sand-hills mixed association: eventually the bunch grass returns. If on the other hand it is burned over or cut, and then grazed, the surface-layers of the soil being hardened, short-grasses come in.

More or less intermediate between the two formations stands the wire-grass association dominated by *Aristida longiseta*. This occurs on Great Plains soils which are rather more sandy than those carrying the typical short grass association, but is included by Dr. Shantz in the short grass formation.

For a full and most interesting description of the vegetation whose characters have been briefly outlined, the reader should consult Dr. Shantz's bulletin already referred to.

The ordinary "dry farming" practice in this region is to fallow the land in alternate years. The surface-layer of dry soil acts as a dry mulch and preserves much of the water of precipitation falling during the fallow year in the deeper layers of soil. Thus a much better crop is obtained during the next year. The proceeding is however exceedingly risky, because a year of extreme drought may upset the calculation, and it is perhaps doubtful if even over a series of years, much advantage is obtained. "Dry farming" in this region scarcely pays except in association with ranching.

Of abundant ruderal weeds the so-called Russian thistle (*Salsola pestifer*) is the most conspicuous. This and some other species (e.g., *Amaranthus gracizans*) belong to the class of "tumble weeds," i.e., they easily become uprooted or broken off and blow about the plains where they may often be seen caught in lines at the wire fences. *Salsola* shows very beautifully, when growing on the edge of a crop bordering on fallow, the marked effect of differences of water-content of the soil in determining root-growth. The roots of such a plant are all bent out, sometimes at right angles to the vertical axis, away from the crop and towards the fallow, and such plants are much larger and more luxuriant than those growing actually among the crop-plants. Similarly on the edge between a crop and an area of short grass, the Russian thistles have their roots bent *towards* the crop where the competition for water is less severe than in the short grass area. These phenomena give an excellent idea of the very severe competition for soil water that must go on in any closed association in this region.

Leaving Akron in the late afternoon of August 11th, the party travelled to Denver and thence southward to Palmer Lake on the edge of the Rocky Mountain foothills. Before reaching Denver an irrigated region is entered, a region in which a supply of river water is available for irrigation; and here the country is much more closely occupied by crops, and these are, on the whole, much more luxuriant than in the "dry farming" region further east. All along this part of the route the "sweet clover" (*Melilotus alba*) is exceedingly abundant and luxuriant as a roadside weed, far more so than in Europe, often forming pure stands for some distance along the wayside: indeed the abundance and luxuriance of this plant right through the continent from east to west, except in the driest and most alkaline regions, is a very striking phenomenon to a European. It seems that in temperate North America the plant has found much more favourable conditions than exist in Europe, its native

home. *Typha latifolia* and *Scirpus validus* (?=*lacustris*) occur here and there in wet places, along the sides of the railroad tracks and elsewhere right through the prairie and plains regions, growing in places where no open water exists, rather a striking difference from their ordinary European habitats.

THE ROCKY MOUNTAIN FOOTHILLS.

August 12th was spent in an excursion from Palmer Lake into the "Black Forest," a great area of *Pinus scopulorum* (the Rocky Mountain form of the far western Yellow Pine, *P. ponderosa*), stretching out from the mountains on higher ground into the Great Plains, and with an average elevation of 1,000 feet above the latter. It occupies the watershed between the Platte river on the north and the Arkansas river on the south. The undergrowth of the pine forest consists largely of *Arctostaphylos Uva-ursi*, with *Muhlenbergia gracilis*, *Carex scoparia*, etc. The highest ridge of the forest has Douglas fir, representing the next higher stage in the Rocky Mountain zonation, but this ridge was not visited.

The pine forest is fringed with "chaparral" or, as we should call it, scrub,¹ dominated by the three species *Cercocarpus parvifolius*, *Quercus Gunnisonii* (a scrub oak), and *Rhus trilobata*, which are often mixed, but sometimes zoned. According to Professor Clements they have different water demands in an ascending series, and correspondingly the last-named species extends furthest eastwards. The chaparral often forms fairly dense thickets and casts a deep shade. It shelters various shade forms of species which also grow in the grassland outside, such as *Achillea lanulosa* (close to *A. millefolium*), *Helianthus rigidus*, *H. pumilus*, *Agrostis hiemalis*, as well as shade species—such as *Fragaria vesca*—which also occur in the Rocky Mountain forest.

The grassland which generally occupies the floors of the natural amphitheatres—the slopes of which are fringed with chaparral, the higher ground being covered with pine forest—is part of the Great Plains grassland formation, but is not here dominated by short-grass, and consists largely of *Festuca ovina* (forma *ingrata*) *Bouteloua hirsuta*, and *Kaeleria cristata*, with *Achillea lanulosa*, *Petalostemum* sp., *Artemisia canadensis* and *Arenaria Fendleri*, abundant. This grassland also covers the strikingly flat tops of the foothill "mesas"—the dissected remains of an old alluvial plain—and here is often dominated by the grama-grass, *Bouteloua oligostachya*, with *Muhlenbergia punctata* and *Agropyrum Smithii*.

¹ To be distinguished from the "true" Californian chaparral which is sclerophyll scrub quite analogous to Mediterranean *maquis*.

forming nearly pure local patches (societies in the English use) and much *Opuntia* and *Mamillaria vivipara*, giving quite a typical Great Plains vegetation.

On the evening of August 12th the party travelled—again southward—to the flourishing city and health resort of Colorado Springs, where the night was spent. On August 13th the party drove west to Colorado City, spending the day among the foothills, and examined the vegetation of Bear Canyon, of the Niobrara Limestone, which here forms a prominent foothill ridge, and of the "Garden of the Gods" with its towering masses of red Triassic or Permian sandstone. In this region the foothill thicket (chaparral) alternates with grassland and on the rocky slopes the most northern limit of the Pignon-Juniper formation is encountered. This last formation, dominated by *Pinus edulis* and *Juniperus monosperma* (*Sabina scopulorum*), has an immense extension to the southward through New Mexico and Arizona into Mexico. At this northward limit its specific flora is relatively poor, being mainly characterised by *Stipa Scribneri* with the fern *Cheilanthes Feei* on the rocks. It takes the rocky slopes with shallow soil, while the chaparral prefers the gentler slopes with a deeper soil. Examples of river bottom woods dominated by *Populus Sargentii* (the western form of the cottonwood) and with *P. angustifolia*, *Acer Negundo*, etc. associated, sheltering quite a characteristic river-bottom vegetation, were seen in Bear Creek Canyon. In the evening the party walked from Manitou (6,500 feet) at the foot of the mountains up Engelmann Canyon which carries the Pike's Peak cog-railway, to Minnehaha-on-Ruxton (8,330 feet) a beautiful spot in the Douglas fir-wood which covers the lower slopes of the Rocky Mountains, and here they were accommodated in Professor Clements's two bungalows and in the inn.

ROCKY MOUNTAINS—PIKE'S PEAK REGION.

The next week was spent at Minnehaha as headquarters, and almost daily excursions were made to places in the neighbourhood, including one to the top of Pike's Peak (14,109 feet) and another (2 days) to the top of Mount Garfield (12,365 feet). The opportunity thus afforded of studying the vegetation of this region in a more or less leisurely way, and the restfulness of the comparatively prolonged sojourn in so delightful a spot as Minnehaha, right in the midst of practically untouched forest and with a glorious view down the canyon over the Great Plains, were much appreciated by the party, who owe a special debt of gratitude to Professor and Mrs. Clements

for their unwearying kindness and the great trouble taken to secure the comfort and convenience of all the members. During the stay at Minnehaha, Professor Engler of Berlin joined the party.

The Rocky Mountains in the Pike's Peak region are formed of Archæan granite weathering very easily into rough rounded fragments, largely ranging from 10 to 15 or 20 millimeters in diameter. This coarse gravel forms the very characteristic gravel slides which occupy many of the mountain slopes, and furnish the basis of the soil on which the succession to forest is developed.

Minnehaha is situated in the Douglas fir (*Pseudotsuga-mucronata*) zone, and all stages of the succession from bare gravel-slide to Douglas forest may be studied in the immediate neighbourhood. These stages may be summarised as follows, according to Professor Clements: (1) Gravel-slide association with *Aletes acaulis*, *Eriogonum flavum*, *Mentzelia multiflora*, *Smilacina (Vagnera) stellata*, etc., forming an open (pioneer) association with large areas of bare gravel between the plants. This association begins to colonise the gravel-slide directly the downward movement of the slide is checked from any cause. The plants all have extensively developed underground parts which ramify in the gravel and by upward growth of the shoot-buds are able to keep pace with the movement of gravel from above which tends to cover them. (2) Half-gravel slide-association with *Elymus triticoides (ambiguus)* and *Muhlenbergia gracilis* largely covering the ground. *Rubus deliciosus*, *Gilia aggregata*, *Geranium cæspitosum* and in places *Yucca glauca* are conspicuous species in this association. The half-gravel slide may be followed by (3) the thicket association, which may be regarded as the upward continuation of the chaparral which fringes the Great Plains. Indeed *Quercus Gunnisonii* is still found at this level, but dies out immediately above, and the thicket formation is here mainly composed of *Holodiscus dumosus*, *Rubus deliciosus*, and *Opulaster opulifolia (monogyna)*, with *Jamesia americana* in company with the two last species extending to much higher altitudes. (4) The Pine forest association, dominated by *Pinus scopulorum* and in places by *P. flexilis*. The pine forest has an undergrowth, more or less discontinuous, especially of *Arctostaphylos Uva-ursi*, with *Pentstemon* spp., *Drymocallis (Potentilla) fissa*, etc., and the frequent tall grey-white spikes of *Frasera speciosa*. (5) The Douglas fir-wood association dominated by *Pseudotsuga mucronata* freely mixed with Engelmann spruce (*Picea Engelmanni*). The latter tree is dominant and forms forest at higher levels up to

11,000 feet. Both shelter a fairly rich ground-vegetation essentially similar throughout. When growing in very close stand rejuvenation in both forests ceases and the ground becomes almost bare of vegetation. The shrub-layer normally consists of *Acer glabrum*, *Betula fontinalis*, *Opulaster opulifolia*, *Holodiscus dumosus*; and local dominants of the ground-vegetation are *Thalictrum sparsiflorum*, *Erigeron macranthus*, *Solidago Parryi*, *Mertensia pratensis*, *Fragaria vesca*.

After a burn of the mature forest aspen (*Populus tremuloides*) wood normally appears and is eventually replaced by Douglas fir. There is, however, another aspen association—the aspen-meadow, developed in the broader valleys at higher altitudes. The meadow-vegetation is much the same in the open as under the light shade of the aspens. Towards the wetter ground on the edges of the streams this is replaced by a birch-willow thicket. *Potentilla (Dasyphora) fruticosa* is a very conspicuous plant of such habitats.

The stages of the main (gravel-slide—Douglas forest) succession alternate very strikingly on the slopes of the valleys about Minnehaha. Generally speaking the south and west-facing slopes are in earlier stages of the succession than those facing north and east.

In extreme cases a bare gravel-slide may face a Douglas wood on the opposite side of the valley. This, according to Professor Clements, is because of the prevalent west winds which help fires and keep the soil disturbed. On the south-facing slopes also the conditions are evidently drier and the succession less rapid. On the south-facing slope of Ruxton glen indeed there is a complex mixture of different stages of the succession, and a great deal of telescoping often occurs, while many species come in out of their places, *e.g.*, Pine and Douglas fir sometimes directly follow on gravel-slide. A certain amount of scepticism was indeed expressed by some members of the party as to the generality of the succession outlined above, the view being taken that the different associations were likely to be stable under the conditions to which they were exposed. The present writer, while accepting the succession given above as normal, with much disturbance and telescoping owing to various causes, was inclined to doubt whether the pine forest, a very distinct association, occurring specially on wind-swept gentle slopes or on the broad, rounded tops of minor summits, would not in such situations tend to maintain itself indefinitely. Professor Clements's forthcoming book on the vegetation of this region will no doubt

clear up many such questions. What seems to be wanted is a very clear statement, analysis and criticism of the evidence for the continuity of the succession, of the conditions determining the initiation of each stage in the habitat presented by the preceding stage, and of the conditions under which disturbance and telescoping occur.

Space does not permit of an extended account of the vegetation of the upper ranges of the mountains, of which indeed, partly owing to bad weather, we did not see as much as could have been wished.

Above about 9,000 feet Douglas fir forest gives way to forest of Englemann spruce, which has much the same ground vegetation. Professor Schröter noted the following marked differences between the forest of *Picea Engelmanni* and the corresponding Swiss forest of *Picea excelsa*: absence in the former of plants germinating on fallen rotting trunks or on stumps; less humus and no specialised humus-plants; no *Usnea* on the trees. These negative features are no doubt to be attributed to the much drier air. *Picea Engelmanni* sometimes itself forms the upper forest-limit at 11,000 feet, but often gives way to *Pinus aristata*, which in that case forms the actual "timber line" and often presents fairly characteristic "Krüppelholz" forms. Above this there is no alpine scrub-association but we pass at once to alpine-meadow alternating with gravel-slides inhabited by quite a different set of species from those of lower levels. Cushion plants such as *Paronychia pulvinata*, *Arenaria biflora* and *Silene acaulis*, together with such forms as *Haplopappus pygmaeus*, *Senecio taraxacoides* and *Festuca brachyphylla* are the characteristic species. The rock-cleft vegetation contains *Polemonium speciosum*, *Primula Parryi*, *Mertensia alpina*, *Claytonia megarrhiza*, etc.

The alpine meadow consists primarily of *Carex rupestris*, *C. filifolia*, *Festuca brachyphylla* and *Poa* spp., with societies of *Rydbergia grandiflora*, *Polygonum bistortoides*, *Mertensia alpina*, *Castilleja pallida*; and this is the main climax association above 11,000 feet. According to Professor Clements it is preceded in succession on the one hand by alpine gravel-slide, on the other by alpine bog. The top of Pike's Peak itself is covered with "mountain-top detritus," holding a very scanty vegetation. The snow-line is of course well above the summit in this latitude with so low a precipitation—about 28 inches on the summit. There are two or three tiny glaciers in the neighbourhood of Long's Peak, 100 miles to the north.

A feature of the stay at Minnehaha was discussion on vegetation concepts: in particular a discussion in which the divergent views of

the plant-formation were made very clear. Of the two main conceptions, one started with the formation as a purely local phenomenon, with a specific floristic composition, recognising analogies between any given formation and others with similar growth-forms in other parts of the world; the other considered a formation as a universal phenomenon with the same fundamental relations to environment wherever it occurs and represented in different places by communities of different floristic composition. To the acceptance of such a concept the adherents of the former view objected that we have not as yet enough accurate comparative knowledge of analogous plant-communities in different parts of the world to predicate identity of environmental relations, in spite of similarity or identity of growth-form. It is safe—and very satisfactory—to say that the phytogeographers present were all in substantial agreement as to what they meant by a plant-association, and this at any rate is a very distinct first step to that general agreement as to vegetation concepts which must eventually come.

On August 21st the party left their pleasant abode at Minnehaha and returned to Colorado Springs, where the members were most charmingly entertained to supper at the El Paso Club by some of the leading inhabitants of the city, where there is a large Anglo-American colony.

On the following morning, August 22nd, the party left Colorado Springs for Salt Lake City by the Denver and Rio Grande railroad. The route at first lay southward, skirting the foothills, and traversing the formations previously seen. *Atriplex canescens* and *Opuntia arborescens* are however conspicuous here in the Plains formation, and the sage-brush (*Artemisia tridentata*) begins to appear from the south. At Pueblo the line turns west and beyond Canyon City enters the Royal Gorge of the Arkansas river, bounded in places by abrupt cliffs 2,000 feet high. The Pignon-Juniper association is very well developed on the north exposure, with *Opuntia arborescens* largely represented on the south-facing side of the gorge. Further up the gorge this gives place also to the Pignon-Juniper association and then to Pignon alone. *Populus tremuloides* is abundant along the riverside. Further up still the gorge opens out and Douglas fir, Engelmann spruce and aspen appear on the upper slopes of the valley. Eventually a broad valley is entered, sub-alpine meadow containing much *Potentilla fruticosa* with *Picea Engelmanni* and *Pinus Murrayana* (the lodge-pole pine) which is absent from the Pike's Peak region, though it forms a well-marked altitudinal zone

further north. Tennessee Pass, crossing the Continental divide at 10,246 feet, was reached about dusk and here are close stands of lodge-pole pine—perhaps fire relicts—among great stretches of bare grass-covered mountain.

THE DESERTS OF THE GREAT BASIN.

On the morning of August 23rd the members of the International party awoke to find themselves travelling through the alkali deserts of the basin of the Green River, in the State of Utah. These deserts extend for thousands of square miles within the area of the Great Basin, centering round Great Salt Lake, and in alternation with the sage-brush deserts cover practically the whole of the enormous arid region between the Rocky Mountains and the Sierra Nevada. The dominant plant over wide stretches is the shrubby greasewood (*Sarcobatus vermiculatus*) a shrub about three or four feet high with bright green succulent leaves. The greasewood association alternates with the grey-leaved sage-brush (*Artemisia tridentata*) the most characteristic plant of the whole arid region alluded to. Behind the stretches of level desert rose striking flat-topped hills edged with vertical cliffs running down into fans of talus. For the most part these hills appeared quite bare of vegetation, but on some of the higher ones dark shrubs appeared, probably *Juniperus Utahensis*. By the side of the railroad track were *Salsola*, *Chrysanthemus*, *Cleome lutea*, *Helianthus*, *Gutierrezia*, the yellowness of nearly all the flowers visible being a striking feature. *Melilotus alba*, species of *Salix*, and even *Typha* were seen in places along the track. Where the land was irrigable good crops of oats and alfalfa were being raised, and trees, particularly cottonwoods and Lombardy poplars, were flourishing.

The Wasatch Mountains forming a westward extension of the Rockies and separating the basin of the Green River (a tributary of the Colorado River) from the Great Salt Lake basin were soon entered and the deserts temporarily left behind.

The picturesque Price River canyon, lined with *Populus angustifolia*, *Salix* spp. and *Acer Negundo* along the streamside, was entered at Castlegate, and scrub and coniferous trees, reminiscent of the Rocky Mountains, were soon encountered. In the lateral gullies was scrub of *Quercus*, *Rhus*, *Cercocarpus* and *Fendlera*: *Pinus ponderosa* appeared on the slopes, and soon afterwards Douglas fir. The drier slopes nearer the line were still covered with sage-brush, here growing more densely. On the further side of the Wasatch

Mountains drier conditions again prevailed and the Pignon-Juniper formation (*Pinus edulis* and *Juniperus Utahensis*) was met with.

The country traversed by the railroad between this point and Salt Lake City is practically all irrigated and highly cultivated, with orchards, alfalfa, corn, etc. Of planted trees *Salix babylonica*, Lombardy and other poplars and *Catalpa* are conspicuous.

The party received a warm welcome at Salt Lake City, where they were entertained to lunch—prefaced by a specially excellent cocktail—at the Commercial Club, the remainder of the day being spent in sight-seeing, including a trip to Saltair Beach, where several members of the party enjoyed the peculiar experience of bathing in the Lake. An area of salt flat with *Distichlis*, *Allenrolfea*, *Salicornia*, etc., was visited on the way.

On Sunday, August 24th, the day was spent in the Tooele valley to the south of Great Salt Lake, the scene, during 1912, of very careful vegetation and habitat analysis by Messrs. Kearney, Briggs and Shantz, of the United States Department of Agriculture. The train was taken to Tooele, and the party drove from that point to Grantsville close to the Lake, where the Union Pacific railroad was taken back to Salt Lake City. Stops were made at frequent intervals and the various plant-associations visited.

Tooele valley is about sixteen miles long, thirteen miles broad at its upper (southern) end and seventeen miles broad at its northern (lower) end where it becomes continuous with the flat southern shore of the lake. The difference of level between Tooele (at the upper) and Grantsville (at the lower end) is about 680 feet. The mountains rise steeply from the sides of the valley, whose floor is covered by a great depth of alluvial deposits largely of Eocene age. The area was afterwards covered by the waters of "Lake Bonneville" which occupied the whole area in Pleistocene times. No permanent streams now reach the valley proper. During the Lake Bonneville period the waters of the Salt Lake basin reached a maximum of 1000 feet above the present level of Great Salt Lake, and this level is marked by conspicuous beach lines on the surrounding mountains.

The present climate is semi-arid, evaporation greatly exceeding the average rainfall of about sixteen inches per annum, and Great Salt Lake is still shrinking fairly rapidly.

The natural vegetation of the valley shows a very striking zonation of associations roughly parallel with the lake shore. These are in general correlated with the total salt-content of the soil, but no correlation was found with the chemical composition of the soil

solution. The soils of the Tooele valley are all more or less saline, with the exception of that of the sage-brush (uppermost) association, and that of the sand hills mixed association (which was not visited by the party).

The following associations were distinguished by the Department of Agriculture workers and demonstrated to the international party.

(1). Sage-brush association dominated by *Artemisia tridentata*. This occupies the highest alluvial fans and benches nearest the mountains and has the most sandy soil (with the exception of the sand hills—not considered here), the lowest moisture equivalent, and the lowest salt-content (.03 to .07%) of any of the associations. At the time of this visit the association was very poor floristically, the dominant sage-brush being practically pure, with societies of *Gutierrezia* and some *Agropyron spicatum*. There is, however, a distinct vernal flora coinciding with the rains of May (the wettest month, averaging 2.4 inches), and containing *Phlox*, *Castilleja*, *Delphinium*, etc. During the summer the surface foot of soil is dry, the water-content sinking below the wilting point, and the next few feet of soil are similarly dry in late summer. *Juniperus Utahensis* occurs in this association near the mountains.

(2). *Kochia vestita* association. This occupies the next zone and is again nearly a pure association of the dominant. The soil is more clayey, the surface foot to which the roots of *Kochia* are confined being leached of salt (surface foot .12%, fourth foot 1.11%). The moisture equivalent is a good deal higher than in the sage-brush association, the summer water-content being still below the wilting point.

(3). Shadscale association, dominated by *Atriplex confertifolia* occupying the next lower zone does not differ markedly in physical factors from the previous association.

(4). Greasewood-shadscale association dominated by a mixture of *Atriplex confertifolia* and *Sarcobatus vermiculatus*. The moisture equivalent of this association does not differ much from those of the two last, but the average summer water-content is much higher, and except in the surface foot available water is present during the summer. The salt-content is decidedly higher at all depths, though the leaching effect is still observable in the surface foot. This is apparently the factor which brings in the greasewood, a pronounced halophyte. It is said that the availability of the water-content is

¹ The quantity of water, expressed as a percentage of the dry weight of the soil, retained by the soil against a centrifugal force 1,000 times the force of gravity.

not decreased by the high salt-content; and this is in line with most of the modern work on the physiology of halophytes. *Suaeda Moquinii*, another marked halophyte, forms societies in this association.

The secondary species are much the same throughout this series of associations—*Chrysanthamus graveolens* and *Gutierrezia Sarothrae* being the most conspicuous species.

(5). We now come to the salt flat association, dominated by *Allenrolfea occidentalis* (a *Salicornia*-like plant with alternate instead of opposite leaves) or alternatively by the grass *Distichlis spicata* or by *Salicornia Utahensis*. In this association the high salt-content (1 to 1·25%) which is present at the greater depths under associations (2) to (4), extends to the surface foot of soil, the water table is much higher, and there is available water at all depths during the whole year. The association extends to the edge of the lake and consists of extensive mud flats covered in summer with a glistening white crust of salt and broken by low ridges and hummocks. The vegetation is of an open type.

There is another association strongly irrigated by springs, etc., which has been called the marsh mixed association. It is less saline than (4) and (5) and contains a more varied flora including *Sporobolus airoides*, *Juncus balticus*, etc. This is dependent on local irrigation and does not form part of the series described above.

There is probably no case in which the physical factors determining the occurrence of a series of associations have been worked out so satisfactorily and completely as in these associations of Tooele valley, which appear to be typical of a large part of the Salt Lake basin.

Where the land is irrigated good crops are raised, and the Lombardy poplars are specially fine.

ARID REGIONS OF THE SNAKE AND COLUMBIA RIVER BASINS.

About midnight the party left Salt Lake City by the Oregon Short Line, and the next two days were spent mainly in the train, traversing the states of Idaho, north-eastern Oregon and Washington. During the whole of August 25th the train traversed sage-brush desert in the Snake River valley (Idaho) from Pocatello (Idaho) to Huntingdon just over the Oregon State line, which was reached in the evening. The monotonous grey sage-brush association with occasional patches of grass (*Agropyron*, etc.) and here and there the bright yellow-flowered *Chrysanthamus*, was broken only by

occasional cultivation, the isolated farms invariably sheltered by belts of the ubiquitous Lombardy poplars. During the night we traversed the Blue Mountains, and in the morning were in the Columbia River basin. Entering the state of Washington at Wallawalla we traversed during the whole day that remarkable region of eastern Washington known as the Great Plain of the Columbia River. This immense region, covered by a great basaltic lava-sheet weathering into a fine dust-like soil, is a very important agricultural area in spite of its low rainfall (fourteen to twenty inches). Typical dry farming with wheat and summer fallow alternating is here practised. The hills as far as the eye could reach were entirely under the plough with scarcely a trace of natural vegetation visible, the only variation in the uniform grey tone occurring at the lines between the yellower wheat stubble and the browner fallow. For hour after hour we travelled through this perfectly uniform landscape. In the valleys on the irrigated land were fruit orchards and the usual rows of Lombardy poplars. The roads were mere dust tracks except where they had been "paved" with wheat straw. Such fragments of vegetation as could be seen was either dry "prairie" of *Agropyron spicatum* or occasional stretches of sage-brush now much burned up by the great heat.

In the evening the party arrived (very late) at the important and flourishing city of Spokane, where the members were received by a committee of citizens and driven in automobiles through the brightly lighted streets to the famous Davenport's Café—said to be the best restaurant in all the north-west—entertained to a peculiarly excellent supper, perhaps the best meal partaken of throughout the trip, and, after speeches, were driven back to the station. Short as was our stay in Spokane it formed a most charming and exceedingly welcome interlude in the long railroad journey.

The early morning of August 27th saw our arrival at North Yakima, in the centre of a district which has recently undergone rapid agricultural development. The sage-brush land of which the floor of the Yakima River valley consists, makes, when irrigated, a very favourable soil both for wheat and orchard cultivation. The party were again received by a local committee and taken in automobiles through the beautifully kept pear and peach orchards, where we inspected the process of packing the fruit and stowing it in ventilated and refrigerated fruit cars drawn up on branch railroad tracks immediately outside the packing sheds. The city of North Yakima showed very clearly the evidences of recent great prosperity. The

neat little houses with beautifully kept vividly green grass and gay flower beds, contrasted strikingly with vacant lots of waste land not yet taken up, and great stretches of well-tended orchard. Unfortunately there was no time to see the primitive sage-brush land, of which none is now left in the immediate neighbourhood of the town. The peaches were ripe and were much appreciated by the members of the party.

NORTH-WESTERN CONIFEROUS FORESTS.

North Yakima was left about midday, and during the journey to Tacoma (160 miles) the Cascade Mountains were crossed, an important range running north and south parallel to, and about 100 miles from, the Pacific coast, extending from British Columbia southward for several hundred miles to the southern limit of Oregon, where they become continuous with the Sierra Nevada. The Cascade range has several isolated peaks rising above 14,000 feet, of which the chief is Mount Rainier, whose snow-covered summit was seen to the south from the train. The ridge was crossed through Stampede Tunnel two miles long at 2,810 feet, the overlying pass having an elevation of 3,980 feet. The Cascades form a very important barrier between the western coastal region of high rainfall (131 inches is reached in some places) and the arid region to the east through which we had been travelling and in which the rainfall is generally considerably below 20 inches and may be as low as 7 inches in the year. This striking climatic difference is of course reflected in the vegetation. As the ridge is ascended from the east the sage-brush vegetation gradually gives place to *Pinus ponderosa*, which increases in numbers and is itself replaced by Douglas fir (*Pseudotsuga mucronata*) associated with *Thuja gigantea (plicata)* and *Tsuga heterophylla*.

Thus we entered the wet north-western conifer region of which the Douglas fir is the typical dominant. Its growth here is immensely more luxuriant than in the Rockies, and it is associated with other species, both of trees and of ground-vegetation, though some of the Rocky Mountains species are still present. Much of this area has been cut over and burned, and is now a wilderness of charred stumps and weeds which have replaced the once magnificent forest. The forests on the watershed are, however, National Forests, in the hands of the Federal Government, and these are leased to contractors who fell the timber under the direction of the Government foresters, provision being made for proper regeneration. The forest lands in the hands of private lumber companies are completely cleared of timber

and are often subsequently burned over more than once, effectually preventing the return of the forest trees. The land is then abandoned till it can be sold for farming, at a very low price, e.g., \$15 an acre, but the very heavy cost—at least \$100 an acre—of clearing the ground of tree-stumps imposes a charge so heavy that farming is often unremunerative.

The night of August 27th was spent at the large city of Tacoma on the southern extremity of Puget Sound, and on the following day the party travelled in the morning to Kapowsin where they spent part of the day at a lumber camp as the guests of the Tacoma and Saint Paul Lumber Company. The land belonging to this company is situated on the foothills of the Cascades and once bore splendid Douglas forest, most of which has now been removed. Portions of as yet untouched forest were visited by the party, and presented a magnificent specimen of virgin mesophytic forest.

The forest was dominated by *Pseudotsuga mucronata*, in close stand, often making up 90% of the forest, the average height of the trees being 200 feet. Mature trees are 300 to 400 years old, and 6 or 8 feet in diameter at the base. Some giants measure as much as 14 feet across and these may approach an age of 1,000 years, though in general trees of over 500 years are rare. Associated with *Pseudotsuga* are *Tsuga heterophylla* and *Thuja gigantea*, and also *Abies grandis* and *A. nobilis*. The coastal species *Picea sitchensis* is rare. Of small trees or shrubs, *Acer macrophyllum* is common; *A. circinatum* and *A. glabrum* also occur; also *Rhamnus Purshiana*. The red-berried huckleberry, *Vaccinium parvifolium*, four or five feet high, occurs, and the Devil's Club, *Echinopanax (Fatsia) horrida* with its tall stout prickly stems and large palmately lobed leaves is a great feature under the forest shade. Of ferns, *Polystichum munitum*, the "Christmas fern," *Adiantum pedatum*, var. *aleuticum* and *Blechnum boreale* are common, and the conspicuous lichen often covers the dead branches of the trees *Equisetum sylvaticum*, *Oxalis* sp. (close to *O. Acetosella*) *Tiarella*, and various other shade-forms are found on the ground.

After lumbering various quickly spreading plants at first colonise the soil—conspicuous among which are *Epilobium angustifolium* and *Anaphalis margaritacea*. A species of *Senecio* is also in evidence. *Pteridium aquilinum*, which is absent from the heaviest forest, comes slowly in, and shrub-genera such as *Alnus*, *Salix*, *Corylus*, *Sambucus*, also increase. The conifers come back pretty quickly in normal regeneration, but, as has been said, these areas are so often repeatedly burned over that the young trees are destroyed and all chance of

regeneration vanishes. The derelict land left after these repeated burnings is covered with great stretches of weeds, and presents an indescribable appearance of waste, ruin and desolation, which considerably depressed various European members of the party.

On leaving Kapowsin the train was taken up country as far as Ashford, through the splendid canyon of the Nisqually River, whose sides are still largely covered with fine Douglas forest. Much of this country too has been devastated by the lumbermen. We were told that even so recently as 1900 the ride from near Tacoma up to Mount Rainier was through untouched Douglas forest all the way, with but a few insignificant clearings at intervals.

From Ashford the automobile journey up to the National Park Inn at Longmire’s Springs is partly through the Rainier National Forest and mostly within the Mount Rainier National Park. In a National Forest lumbering is carried on by private individuals or companies under the direction of the Government foresters, but a National Park is a real nature-reserve in which nothing is allowed to be touched except by special permit. The great National Parks of the west, of which the Yellowstone and the Yosemite are the most widely known examples, form one of the possessions of which the United States may most justly be proud. Three of them were visited by the international party in the course of their travels.

The lower part of the Mount Rainier Park is covered with typical and often very fine Douglas forest, though scarcely so fine as the Douglas forest of the lower hills near the coast, which, being in private hands, has already almost disappeared. The dominant Douglas fir is often very pure, and the vegetation is of the same general type as that seen in the unfelled forest near the lumber camp already described. The trees, considering their immense size, grow pretty close together and the shade is very deep. Huge fallen logs lie prostrate in all directions, so that rapid progress through the forest is impossible. *Tsuga heterophylla*, much more tolerant of shade than *Pseudotsuga* and so regenerating freely in the Douglas woods, *Thuja plicata*, also tolerant of shade, *Abies grandis* and *Picea sitchensis*, enter into the composition of the forest in various proportions. At about 300 years of age, according to Mr. Munger, a Government forester who was with the party in the Rainier forests, Douglas fir begins to suffer, and as the tree does not reproduce itself under its own shade it gradually gives place to *Tsuga* and *Thuja*. On this view a *Tsuga*-*Thuja* forest is the ultimate type in this area, and there would be no pure Douglas stands if it were not for the forest fires which allow the succession to begin

over again. The causes of the occupation of so much of the country by Douglas forest would then be the long duration of the Douglas stage and the frequency of fires. This view is not, however, shared by all authorities well acquainted with the country. *Pseudotsuga* comes in very early on land once burned over.

Arbutus Menziesii, whose headquarters are in the sugar-pine (*Pinus Lambertiana*) area on the Californian Sierra, extends up the coast through Oregon as far as Vancouver Island, where it occurs mainly on warm dry slopes. A few trees occur so far inland as this Rainier area. The distribution of this species furnishes an interesting parallel with that of *Arbutus Unedo* in Europe, whose headquarters are in a warm dry region, but which extends up the west coast so far north as south-west Ireland. In both cases the mild winters of these northern coast-regions are no doubt the factor which makes such a distribution possible.

The shrubby undergrowth consists of *Acer circinatum*, *A. glabrum*, *Ribes bracteosum*, *Rubus spectabilis*, *Vaccinium parvifolium*, *Berberis nervosa*, *Gaultheria Shallon*, etc. These and the ground-flora form, however, a very open vegetation on account of the dense shade. In clearings or on areas recently burned over *Epilobium angustifolium* and *Pteridium aquilinum* are very conspicuous, exactly as they are in similar situations in north-west Europe. In the deep shade of the forest itself the herbaceous vegetation is rather sparse and consists of such species as the tall Devil's Club (*Echinopanax horrida*) which is abundant and conspicuous, *Cornus canadensis* (a northern herbaceous species much like the European *Cornus suecica*), *Maianthemum bifolium* var. *dilatatum*, *Smilacina* sp., *Tiarella*, etc., with abundant ferns—*Blechnum boreale*, *Polystichum munitum*, *Phegopteris Dryopteris*, *Athyrium cyclosporum*. These together with many of the angiospermous herbs frequently grow on the immense fallen logs met with in every direction and covered with thick carpets and cushions of mosses and liverworts.

Dicotyledonous trees are practically absent from the Douglas forests, but often form a belt along the stream-sides. *Alnus oregana*, *Acer macrophyllum* and *A. circinatum* are the chief species in such situations, with *Populus trichocarpa* (closely allied to *P. balsamifera*), and *Fraxinus oregana*.

The Douglas woods extend up to about 2,000 or 2,500 feet, and as one ascends are gradually replaced by mixed woods of *Abies amabilis*, *A. nobilis*, *Tsuga heterophylla*, *Pinus monticola*, *Chamæcypris nootkatensis* (the Alaska cedar). The ground-vegetation

contains many of the same species as in the lower forest, with such forms as *Linnaea borealis*, *Clintonia*, *Pterospora andromedea*, etc.

MOUNT RAINIER.

On the morning of August 29th, after a night spent at Longmire's Springs, the party made their way up the upper Nisqually valley through the coniferous woods just mentioned, past the snout of the Nisqually Glacier, and spent two nights at the "Camp of the Clouds" situated in the sub-alpine parkland at 5,500 feet, above the limit of continuous forest. August 30th was spent on the slopes of Mount Rainier, and on August 31st the party returned to Tacoma. The sub-alpine meadowland round the "Camp of the Clouds" contains a great wealth of beautiful herbaceous forms, including *Valeriana sitchensis*, *Castilleja oreophila*, *Pulsatilla occidentalis*, *Gnaphalium lanceolatum*, *Eriogynia pectinata*, *Hieracium gracile*, *Polygonum bistortoides*, *Lupinus Lyellii*. The trees, which are scattered in clumps and lines, are mainly *Abies lasiocarpa*, a tall narrow pyramidal tree, which, as "Krüppelholz," forms the actual tree-limit at 6,800 feet. Mount Rainier, a great rounded volcanic cone 14,530 feet high and with the upper 5,000 feet or so covered with snow, towers magnificently above these slopes, which are composed of talus and rock and possess many beautiful alpines, such as *Lupinus Lyellii*, *Saxifraga Tolmeana*, *Antennaria*, *Phlox Douglasii*, etc.

"OAK OPENINGS."

On September 1st the "oak-openings" at Spanaway Lake in the neighbourhood of Tacoma were visited. These are patches of prairie in the middle of rather open woodland of Douglas fir with *Fraxinus oregana* (shore of the lake), *Alnus oregana*, *Acer circinatum*, *Corylus californica*, *Salix* sp. and *Pteridium* abundant on the ground. *Quercus Garryana* was scattered along the edge of the prairie, and the grassland itself was largely composed of a species of *Festuca*, with *Leontodon* sp. abundant, and locally *Pteridium*. *Pseudotsuga* was clearly slowly invading the prairie, many seedlings in all stages of growth occurring on the edge of the grassland. Whether the latter was primitive and the observed invasion part of a secular process not yet complete, or whether these local prairies owe their origin to fires occurring in the thin woodland developed on the rather poor gravel and humus soil, as is perhaps more likely, is a question which remains obscure.

Some members of the party visited the *Nereocystis* beds in Puget Sound.

MEDFORD AND CRATER LAKE.

During the afternoon, evening and night of September 2nd we travelled southwards from Tacoma to Medford on the "Shasta Limited" of the Southern Pacific, one of the crack trains of this line, the excess fares for which had been paid by our kind hosts of the Commercial Club at Medford, Oregon, our next stopping place. Thus the hospitality of our Medford friends began before ever we arrived at their city. It was impressed upon us that during the three days on which we were the guests of the club not a single member of the party was to spend a cent, and indeed it was almost impossible to do so. It is as difficult as it would be invidious to single out the kindness and hospitality shown us at any particular centre for special appreciation, but our treatment at Medford and during the trip to Crater Lake would certainly be hard to forget.

After a rest and breakfast at the Medford Hotel, one of those luxurious and at the same time simple establishments for which the Far West is justly famed, we started in seven automobiles—most generously placed at our disposal and nearly all driven by their owners—on the 85-mile trip to Crater Lake. Medford is situated in the centre of the Rogue River Valley, a district which has recently experienced rapid development and astounding prosperity, mainly from its extensive pear orchards.

Much of the uncultivated parts of the valley plain are covered with a very stony soil supporting a poor growth of grasses such as *Hordeum* and *Aristida*, and locally known as "desert." These stony areas are probably the outwash from old glacial streams. Here and there are isolated trees of *Quercus Garryana*, a deciduous but rather leathery-leaved oak. Near the beginning of the foothills, an open scrub or "chaparral" begins, with *Ceanothus cordulatus* dominant, *Arctostaphylos glauca* abundant and occasional trees of *Quercus Garryana*. As the foothills are entered single trees of the yellow pine, *Pinus ponderosa*, appear among the chaparral, and these increase in number but do not form anything like a closed woodland. The scrub thickens and other shrubs appear, such as the beautiful *Arbutus Menziesii* and various herbs, such as the aromatic *Eremocarpus setigera* and species of *Salvia*. A marked feature of this open woodland is the great development of masses of lichen (*Usnea* and others) and mosses which appear on the tree-trunks and branches. These are doubtful due to the wet and comparatively mild winters of the district.

At a somewhat higher altitude (about 2,500 feet) the Douglas Fir (*Pseudotsuga mucronata*) appears and soon increases in abundance, "chaparral" at the same time disappearing. The Douglas Fir does not, however, dominate the forests as it does in the Rockies or in the northern Cascades. The forests around Prospect, for instance, half-way up from Medford to Crater Lake consist of yellow pine and Douglas mixed with Sugar Pine (*P. Lambertiana*)—whose enormous cones, often 18 inches in length, lying on the ground, are a conspicuous feature beneath the trees—*Tsuga heterophylla*, *Libocedrus decurrens*, *Abies concolor*, *Taxus brevifolia* and the Lodge-pole pine (*P. Murrayana* or *contorta*), the last forming, higher up towards Crater Lake, pure stands of uniform age, springing up where the original forest has been burned. The undergrowth in the denser portions of the forest is formed of *Cornus pubescens*, *Corylus rostrata*, *Castanopsis sempervirens*, *Arctostaphylos* spp., *Acer circinatum*, etc. In more open forest which has been partially cleared there are often pure stands of *Ceanothus velutinus*.

On the higher slopes of the Cascades (5,000-8,000 feet) up to the rim of Crater Lake itself, subalpine forest of *Tsuga Pattoniana* with *Abies nobilis*, *A. magnifica*, *Pinus monticola*, and *P. albicaulis* occur. *Alnus sinuata*, closely allied to the European *A. viridis*, shows good alternation with *Abies* on the steep slopes of the crater leading down from the rim to the lake.

Thus there is a fine and well-marked zonation from the plain of the Rogue River valley up to the tree-limit on the Southern Cascades: (1) semi-arid grassland, (2) scrub or "chaparral," (3) mixed coniferous forest in which *Pinus ponderosa* and *Pseudotsuga* are the leading trees, with *Pinus Lambertiana*, *P. Murrayana*, etc., at higher altitudes, (4) subalpine coniferous forest with *Tsuga Pattoniana*, *Abies*, etc. This is no doubt largely determined by gradual increase of moisture as the mountains are ascended.

Crater Lake itself is a wonderful scenic feature. It occupies an immense crater caused by the subsidence of an old volcanic cone estimated to have been 14,000 feet high. The edge of the present rim reaches in places 8,100 feet, while the level of the lake below is 6,180 feet. The lake itself which has an area of more than 12 square miles, is very deep (2,000 feet in places) and its waters are fresh and very clear and blue. The atmospheric effects are wonderfully beautiful. The weather we experienced there was not all that could be desired—a gale of wind was blowing and driving rain and thick mist alternated. But the warmth of our welcome at Crater Lake Lodge was in strong contrast to the inhospitable weather.

On September 5th the party returned to Medford and were entertained to dinner by the Medford Commercial Club and the University Club of Medford—the ladies of the party by the Women's University Club. On the following morning some of the famous pear orchards, beautifully kept and cultivated, were visited under the guidance of their owners. Mr. P. J. O'Gara, who ably and enthusiastically led the party during their stay, has very largely contributed to the success of the fruit industry by his untiring efforts in counteracting plant-disease and climatic dangers such as frost. The profits made in this industry, particularly on pears, are almost incredible. The thing is done by the utmost care in cultivation and the determination to sell nothing but the best. The consequence is that the very best prices are obtained and the market dominated. The air of happy and abounding prosperity which this rapid and overwhelming success has given to the town of Medford is very striking indeed to a visitor—especially to a European visitor. Everything is new and of the best, everyone is bright, cheerful and confident.

On September 6th the last stage of the journey to San Francisco (445 miles) was entered upon. The railroad runs over the Siskiyou mountains with the magnificent snow-covered Mount Shasta constantly visible to the left. The highest altitude reached by the train is the Siskiyou tunnel at 4,130 feet. Very much the same vegetation is passed through as on the journey to Crater Lake—first grassland, chaparral and oak, the oak trees, as throughout California, often scattered singly in the dry grassland; then *Pinus ponderosa* followed by *Pseudotsuga* at the higher levels. After the first ridge is passed a very dry valley cut off from the mountain moisture is entered. Here there is dry grassland with no trees. The train again ascends to 3,900 feet, passing through fine forest with many species of pine. Then begins the final descent into the Californian plains, the zones of vegetation being passed through in the inverse order. About dusk we reached Shasta Springs and soon afterwards caught our last glimpse of the magnificent snow-covered summit of Mount Shasta.

CALIFORNIA AND THE SIERRA NEVADA.

Early in the morning of September 7th we awoke to find ourselves travelling along the shores of San Francisco Bay with extensive salt marshes skirting the coast. After breakfast and a brief stay at Oakland Station we started on the journey to the Yosemite valley, across the dry and exceedingly hot Californian

plains, which are largely quite treeless, except along the streams. As the foothills of the Sierras are approached scattered trees of *Quercus lobata* appear in the grasslands and arable fields. This is a big graceful white oak 50 or 60 feet high. At Merced we changed onto the Yosemite Valley Railroad and soon began the ascent of the Merced valley. *Quercus lobata* is here replaced by the smaller "blue" oak, *Q. Douglasii*, and more or less scattered scrub begins to appear on the hillsides—at first *Adenostoma fasciculatum*, the "chamisal," with short weak needle-shaped leaves, presenting in mass a dingy green-brown colour. *Adenostoma* often forms pure sheets, alternating with dry grassland containing various species of *Avena*, with *Bromus*, *Poa*, etc. Along the streamside are willows, *Populus trichocarpa*, *Fraxinus*, and the round-leaved *Cercis occidentalis*. The chamisal soon becomes mixed with other shrubs, especially species of *Arctostaphylos* ("manzanita")—a genus exceedingly well represented in this region by a number of very closely allied species difficult to discriminate—*Cercocarpus*, *Ceanothus*, etc., which together form the dense scrub, the true Californian chaparral. Among the chaparral are seen scattered trees of *Pinus sabiniana*—the Digger Pine—a light loose-foliaged pine with very heavy massive cones accompanied by another evergreen oak, *Quercus chryssolepis*, a small tree generally 12 or 15 feet high with somewhat contorted branches and the undersides of the leaves covered with close-set golden scale-like hairs. *Q. Kelloggii*, a deciduous "black" oak, and *Q. Wislizeni*, a small dark-leaved evergreen oak, also appear. The whole aspect of the vegetation of this valley is decidedly mediterranean. The chaparral growth-forms strongly resemble those of mediterranean maquis, while *Pinus sabiniana* recalls the mediterranean *P. halepensis*, and the evergreen oaks correspond with *Q. Ilex* and *Q. suber*, though the American species are far more numerous. *Pinus ponderosa* begins to appear as single trees, though at this level—less than 2,000 feet—only small isolated trees occur. *Libocedrus decurrens* also begins to appear. In the evening El Portal—the terminus of the line and the gate of the Yosemite region, dominated by the steep and lofty hills which here shut in the canyon of the Merced river—was reached.

On the following morning—September 8th—the party continued the journey up the Merced canyon in horse-drawn vehicles. *Pinus sabiniana* and *Quercus Wislizeni* begin to disappear; *Pinus ponderosa* increases; *Pseudotsuga*, though not in quantity, begins to put in an appearance; and among other interesting trees and shrubs met with

are the rare "Californian nutmeg" (*Torreya californica*), *Æsculus californica*, *Rhamnus californicus*, *Rhododendron californicum* (deciduous) and the strongly aromatic "Californian laurel" (*Umbellularia californica*).

The entrance to the Yosemite valley is flanked by the truly magnificent El Capitan rock, a practically vertical wall of granite 3,000 feet high. The valley itself is a canyon or trough with a flat alluvial floor and nearly vertical walls varying from 2,000 to 4,000 feet in height. The floor is still largely park-like, with open stretches of grass alternating with stands of trees—*Pinus ponderosa*, *P. Murrayana*, *Libocedrus decurrens*, *Quercus Kelloggii*. The park-like character of the vegetation is due to the annual fires started by the Indians which kept down the forest growth. Since the district has passed under American control, these fires no longer occur and dense young stands of the conifers are springing up. The south-facing side of the valley bears *Pinus ponderosa* on the rocks and in ravines, and scrub of *Quercus chrysolepis* on the alternating talus slopes. On the top of El Capitan *Pinus Murrayana* and the subalpine species *P. Jeffreyi* occur.

In the afternoon the party drove *via* Inspiration Point and Chinquapin to Wawona. Magnificent views of the Yosemite with El Capitan in front were obtained in ascending the side of the valley through forests of *Quercus Kelloggii*, *Q. chrysolepis*, *Libocedrus* and *Abies concolor* with *Rhamnus californicus*, *Ceanothus integerrimus*, *Acer macrophyllum*, and *Castanopsis* as undergrowth. On the Wawona side the forest was dominated mainly by *Pinus ponderosa* with *Libocedrus decurrens* and *Abies concolor* abundant, both showing very free regeneration. *Arctostaphylos viscida* and *A. patula* occurred in quantity in open woodland with *Cercocarpus* and *Ceanothus cordulatus* in the open and the bipinnate *Chamæbatia foliolosa* often covering the ground in great sheets. At the higher elevations near Chinquapin, *Pinus Lambertiana* increases very much, forming twenty or thirty per cent of the forest growth, and freely springing from seed, like the yellow pine and the other conifers. *Ceanothus prostratus* also appeared here. The Sugar Pine is a magnificent tree, generally exceeding 100 feet in height, and often reaching nearer 200 feet.

Wawona, at the bottom of the valley on the South Fork of the Merced River, was reached late in the evening.

The next day, September 9th, was spent in a visit to the famous Mariposa Grove of Big Trees (*Sequoia gigantea*). The forest

in which the lower and upper "groves" of Big Trees occur is composed of *Abies concolor*, *Pinus ponderosa*, *Libocedrus decurrens* and *Pinus Lambertiana*, all rejuvenating well, the first-named most abundantly. The undergrowth consisted of *Ribes Nevadensis*, *Corylus rostrata*, *Cornus pubescens*; *Ceanothus cordulatus* and other species very abundant, often covering the ground in pure patches; also *Arctostaphylos patula*, *Ribes Roezlii*, *Chamæbatia foliolosa*, the raspberry-like *Rubus Nootkatensis*, *Prunus emarginata* and *Pteridium aquilinum*. The Big Trees themselves occur scattered through the woods, but particularly in groups. There are nearly 500 trees altogether in the Mariposa Forest. Though not regenerating so freely as in the groves further south on the Sierras there is quite good reproduction in places. The Big Trees are of course extraordinarily impressive both in size and height, dwarfing as they do even the great Sugar Pines, but some hours have to be spent among them before one begins to take in their grandeur, and it would be necessary to live among them before one could get anything like a full æsthetic appreciation. The most beautiful trees are those of young middle age (say 500 to 1,000 years old), whose crowns have not begun to round off. The biggest trees, whose diameter is 20 to 30 feet at the base, have a less beautiful form because of their more rounded tops, sparser branching and less dense foliage.

On September 10th the main party drove from Wawona to Glacier Point, the highest point reached in the Sierras, on the 11th came back to El Portal, and on the 12th returned to Berkeley, staying in San Francisco or its neighbourhood till September 15th.

CHAPARRAL, DRY GRASSLAND AND REDWOODS.

Sunday, September 14th, was spent in an excursion to Mount Tamalpais, on the Sausalito peninsula, which lies on the north side across the Golden Gate from San Francisco, and is ascended by electric railway. The mountain is covered with typical Californian chaparral, which has the same general ecological characteristics as mediterranean *maquis* and inhabits regions exposed to the same type of climate. Most of the trees and shrubs seen on Mount Tamalpais had already been encountered on the Sierran foothills: *Adenostoma fasciculatum*, the commonest of all the chaparral shrubs, species of *Arctostaphylos*, *Quercus Wislizeni*, *Q. chrysolepis*, species of *Ceanothus*, *Rhamnus californicus*, *Arbutus Menziesii*, *Umbellularia*, *Castanopsis*, *Eriodictyon glutinosum*, with *Heteromeles arbutifolia*, *Baccharis consanguineus*, etc. *Quercus densiflora*, a common evergreen oak of

the Coast ranges, was scattered here and there. The characteristic alternation of chaparral and dry grassland with scattered oaks was seen here as elsewhere in California.

There are two views of the origin of this grassland. One is that the grassland is a primitive vegetation occupying a drier zone than the chaparral. Thus the southern slopes of the hills behind Berkeley and Oakland are dry grassland and show no tendency to produce chaparral which covers the north slopes. It has been suggested that the scattered oaks so characteristic of it increase and develop up to the limit set by the soil-water supply, which is too scanty to permit of a closed forest vegetation or even of chaparral. Whether this view be true or not, it is evident that species of evergreen oak which remain low and scrubby when growing in thick chaparral, develop into trees in the open grassland, presumably owing to freedom from root competition. The other view is that the grassland has been derived from chaparral by repeated burning of the latter, and that the oaks are relicts of the chaparral, freed from the competition of woody plants. Mr. W. S. Cooper's detailed and extensive investigation of Californian chaparral may be expected to throw much light on all these relations.

A large area of the Mount Tamalpais chaparral was burned over early in July and the vigorous sprouting from the burned stumps that had occurred by mid-September showed very well the characteristic vegetative rejuvenation of chaparral after burning.

The canyons on Mount Tamalpais are full of small redwoods (*Sequoia sempervirens*) and Douglas fir. The redwoods as opposed to the chaparral are said to be confined to the "fog region" so characteristic of the vicinity of San Francisco. The prevalence of cold mist over San Francisco city and the shores of the bay is indeed a striking characteristic, rather unexpected by the stranger. Muir Woods in Mill Valley show a very fine example of primitive redwood forest, in which the dominant tree is associated with *Quercus densiflora*, *Pseudotsuga mucronata*, *Umbellularia* and *Arbutus*, with *Acer macrophyllum*, *Rhododendron occidentale*, the deciduous *Corylus rostrata*, and the magnificent *Aralia californica* and *Aspidium monatum* as the great features of the undergrowth. Other abundant species are *Pteridium aquilinum*, *Myrica californica*, *Gaultheria Shallon*, *Vaccinium ovatum*, *Woodwardia radicans*, *Oxalis oregana*, etc., indicating of course much damper conditions, both atmospherically and edaphically than are present in typical chaparral. Apart from the dominant redwood, the whole facies of this vegetation and

the leaf-form of many of the prevalent trees and shrubs is that of the "laurel type" found in the Atlantic—Mediterranean region and in the sheltered ravines of the Mediterranean foothills. In both cases the "laurel vegetation" possesses several species in common with the chaparral or *maquis*, the adjacent climatic type.

On the Yosemite trip and during the whole stay in the San Francisco region, the international party were received with true Californian hospitality and were guided and generally looked after in the most admirable way, the various local institutions—the University of the California, and the California Botanical Society—vying with one another in their efforts to give the visitors a pleasant and profitable trip. A too short visit was made by some of the party to Stanford University at Palo Alto, where Professor Campbell and Professor Peirce acted as hosts with great charm, and the beautiful buildings of the University were much admired. To Professors Setchell, Jepson and Hall, and to Miss Alice Eastwood, the party were greatly indebted for their kindness during the stay as a whole.

MONTEREY AND CARMEL.

On September 15th most of the party left San Francisco for Monterey and Carmel, where Dr. MacDougal, Director of the Tucson Desert Laboratory of the Carnegie Institution of Washington, took charge of the arrangements till practically the close of the tour at Tucson, Arizona, at the end of the month. Through Dr. MacDougal's efforts a large grant was obtained from the Carnegie Institution for hospitality to the international party, and by his forethought, his genius for organisation, and the unremitting pains, attention and kindness which he lavished on the needs, both physical and intellectual, of his guests, this portion of the tour formed a most brilliant close to a brilliantly successful excursion. To Dr. MacDougal and to all his willing lieutenants, most particularly Dr. Cannon, Mr. Sykes and Dr. Forrest Shreve, the whole party lies under the deepest debt of gratitude.

The Monterey-Carmel district is well-known as the home of a group of very local endemic species, of which the Monterey Pine (*Pinus radiata*) and the Monterey Cypress (*Cupressus macrocarpa*) are the most conspicuous. Forests of the Monterey Pine covers the low dry hills near the coast between Monterey and Carmel, with chaparral or dry grassland in the more open places. Magnificent groves of *Cupressus*, many of the trees tortured by the wind into the queerest shapes, occur on the shallow rocky soil at

Cypress Point, forming the outermost fringe of the pinewoods. *Quercus agrifolia* is very frequent, scattered through the dry grass-land. The landscape, especially between Carmel and Cypress Point, is very striking. The weird wind-forms of the trees, especially *Quercus agrifolia*—*Pinus radiata* seems to be almost unaffected by wind—and the colouring of the landscape in September produce an effect very strange to the eyes of a European, unless it be rivalled in parts of Spain. Brown, brown-green, and light orange predominate. *Usnea* thickly covers the dead branches and twigs on the windward side of the oaks and *Trentepohlia* forms a brick-red feltwork on the dead branches of the cypresses. In the rock-bound bays the enormous fronds of the giant Laminarian seaweeds rise and fall on the Pacific swell. The prevailing brown-yellow tone of the landscape was marvellously enhanced at sunset by a flood of orange light from the west.

SOUTHERN CALIFORNIA.

On the morning of September 17th the party left Carmel and travelled southwards on the Southern Pacific towards Los Angeles, passing through much characteristic Californian country—broad fertile valleys, and hills covered with chaparral alternating with the stretches of dry grassland and scattered evergreen oaks so often mentioned. On crossing the Santa Margarita mountains, a few miles before reaching San Luis Obispo, the party met with quite an exciting adventure. The train was held up for several hours just outside a tunnel, because the next tunnel was on fire. At dusk the word came that we were to be transferred to another train on the other side of the burning tunnel. We had to reach the other train by a narrow path over the chaparral-covered mountain, the chaparral having just been burnt by the fire so that the blackened soil was still hot. Encumbered with our “hand-luggage,” almost more than we could carry for any distance, we struggled along the narrow path, and in the middle of the route met a line of people in the same case, coming from the other train, and “being transferred” to the one we had just left. The slope was steep and it was difficult to pass and keep one’s footing. There were old infirm people, and women with babies and children. It took about an hour to perform the journey of less than a mile, and the scene, lighted up by the lamps and torches of the railway men and backed by the indescribably vivid orange of the Californian afterglow behind the hills, was unforgettable. Everyone was exceedingly kind and

helpful, and the patient uncomplaining way in which those who suffered most took the unpleasant experience was exceedingly striking. As we passed the burning end of the tunnel the fierce flaming of the gigantic beams fallen from the roof across the opening was very impressive in the gathering night. The fire was so serious that after repeated and ineffectual efforts to put it out the tunnel had to be sealed, and the coast-line—the main route from San Francisco to Southern California—was completely blocked for about two months while the tunnel was repaired. Eventually we arrived at Santa Barbara in the middle of the night and stopped there instead of at Los Angeles as had been intended.

The morning of September 18th was spent at Santa Barbara, a beautiful place with lovely gardens full of sub-tropical flowers and humming birds. The old Spanish mission is absolutely a bit of Southern Europe transported to America, and very pleasant to the homesick European. The town is backed by chaparral-covered mountains, very Mediterranean in aspect. Los Angeles, the busy flourishing metropolis of southern California, was reached at night, and after dinner in the town, the night-train was taken to Mecca, where a stop was made to visit the Salton Sea.

THE SALTON SEA.

On the morning of September 19th we woke to find ourselves in desert, and that of a very arid type—with an average yearly rainfall of less than 3 inches and a maximum evaporation of 120 inches. After breakfast we drove from Mecca several miles across the desert to the edge of the Salton Sea, a lake formed in the bottom of a salty "sink" by the accidental inflowing of water from the Colorado river. The whole of this basin is considerably below sea-level. The flat desert supports an open shrub-vegetation consisting chiefly of *Prosopis* spp., *Larrea tridentata*, *Parosela* spp. and *Cercidium (Parkinsonia) torreyanum*. The lake itself has rapidly receded since the influx of water was stopped in 1907 and is still receding year by year owing to the high evaporation. The dead trees and shrubs are being exposed by the receding waters. On the emersed beaches plants rapidly spring up, and this vegetation gradually changes as the conditions become more arid. At first the beach-line is colonised by growths of *Typha latifolia*, *Scirpus americanus* and *Salix nigra*, the last-named growing to a considerable height. *Distichlis spicata*, *Spirostachys (Allenrolfea) occidentalis*, and *Atriplex* spp.

soon appear on the salty soil, and are eventually replaced by the typical desert-vegetation, *Prosopis*, *Isocoma*, etc.¹

In the afternoon we visited a fine date orchard at Mecca, where the finest strains of date palm from all parts of North Africa are tried. The date industry of this region is growing rapidly.

On this afternoon the highest air-temperature encountered on the tour was registered. In the Middle West we had more than once had temperatures of over 100°F., but at Mecca a thermometer showed 115°F. in the shade. On the shore of the Salton Sea, where the relative humidity is high for such temperatures, owing to the proximity of the great body of water, the heat was decidedly trying. In the date-orchard the screened thermometer registered 108°F. at 5.30 p.m.

TUCSON AND THE ARIZONA DESERT.

During the night of September 19th we continued our railway journey along the edge of Salton Sea and crossed the Colorado River into Arizona only seven miles from the Mexican frontier. In the morning we were travelling through the Arizona desert and approaching Tucson, and here we caught our first glimpse of that imposing plant *Carnegiea gigantea* (*Cereus giganteus*), which stands up here and there as a column 20 or 30 feet high in the midst of the desert scrub.

The whole of September 20th was spent at the famous Desert Laboratory two or three miles outside the town of Tucson, on the lower slopes of Tumamoc Hill. Here Dr. MacDougal and the staff of the Laboratory had spared no pains to make our visit as pleasant and profitable as might be during the short time available. The different members of the staff gave short informal accounts of the researches being conducted at the Laboratory, many of them of great interest and importance. Dr. Forrest Shreve gave us an instructive little talk on the climate of Tucson and its relation to the vegetation. Dr. Livingston gave a demonstration of his atmometer cups, now widely used throughout the United States.

This is not the place to give any account of the work carried on at the Desert Laboratory, which is fully dealt with in the annual reports issued by the Carnegie Institution and in the other publications emanating from this important centre of research. It is sufficient to say that Dr. MacDougal and his fellow-workers are continuously making determined attempts to penetrate to the more

¹ For a very full account of the colonisation of the emersed beach lines see D. T. MacDougal, "The Salton Sea," Carnegie Institution of Washington, 1914. See Review, *New Phytologist*, October, 1914, p. 280.

fundamental questions of desert ecology, and with a large measure of success.

The vegetation of the neighbourhood of Tucson is fairly familiar to ecologists from the papers of Dr. MacDougal, Dr. Spalding and other workers at the Desert Laboratory, and no good purpose would be served by attempting a necessarily superficial description of it here. The country may fairly be called "semi-desert," since it has a distinct summer rainfall period in addition to the winter period and is thus climatically different from "true" desert. Correspondingly the vegetation is more luxuriant and much more numerous in individuals than is the case in the typical North African deserts. It is the "dry bush steppe" of various Continental writers. The dominant growth-form is the fair-sized shrub, much bigger than the North African undershrubs, with small highly xerophilous and sometimes deciduous leaves. The leading species are *Larrea (Covillea) tridentata*, *Parkinsonia microphylla* and *Fouquieria splendens*. Here and there the branched columns of the giant cactus rise far above the scrub and, locally, species of *Opuntia* and *Echinocactus* occur in considerable numbers. Only in places do grasses or other herbs form anything like continuous ground cover. Along the channels and "washes" the mesquite (*Prosopis*) occurs abundantly and grows quite luxuriantly, together with species of *Populus*, *Salix* and *Fraxinus*.

SANTA CATALINA MOUNTAINS.

On the afternoon of September 21st the party motored across the desert to the foot of the Santa Catalina range, on which the next few days were to be spent. The evening meal—taken at a camp at the base of the mountains amid a grove of giant cacti (*Carnegia*)—was made quite luxurious by the excellence and variety of the food (which included a huge supply of ice-cream !), and just before sunset a start was made up the mountains for "Oak Camp" where the first night was to be spent. The lowermost slopes are covered by a magnificent stand of *Carnegia* mixed with *Fouquieria*. At a somewhat higher level these disappear and the first evergreen oak (*Q. oblongifolia*) appears, with *Juniperus pachyphloea*, *Arctostaphylos pungens*, *Dasyliion Wheeleri*, *Nolina microcarpa*, etc. The camp in "Soldiers' Canyon," nearly 5,000 feet above the sea among the evergreen oaks and accompanying sclerophyll scrub, was reached long after dark. September 22nd was spent among the vegetation of this region, which is a transition between semi-desert and sclerophyll vegetation. On the morning of September 23rd the further

ascent of the range was undertaken. Among the evergreen oaks (*Q. emoryi*, *Q. hypoleuca* and *Q. arizonica*) the dwarf *Pinus cembroides* (one of the "pignon" group, close to *P. edulis* and *P. monophylla*) appears, and about 5,500 feet it increases and permeates the whole open woodland. "Manzanita Ridge" is covered with scrub among which *Arctostaphylos* spp. are conspicuous. Towards 6,000 feet the tall southern yellow pine (*P. arizonica*) comes in, and shortly afterwards *P. chihuahuensis*. Here and there a few Douglas spruces and *Pteridium aquilinum* also appear. On the north-facing slope descending into Bear Canyon—the site of the next camp—there is a closer but still sparse wood of yellow pine with *Arbutus arizonica*, *Ceanothus Fendleri*, *Arctostaphylos Pringlei*, *Juglans major*, *Quercus Gambelii*, *Rhus elegantula*, *Berberis Wilcoxiana*, etc.

On the morning of September 24th most of the party returned to Oak Camp *en route* to Tucson and the Grand Canyon of the Colorado River, but a party from the Desert Laboratory accompanied by a few members of the international party continued the trip to Mount Lemmon on the summit of the Santa Catalina range. The south-facing side of Bear Canyon up which the route lay is a nearly vertical slope so dry and fully exposed to the sun that many desert plants go right up to the summit between the evergreen oaks and manzanita scrub. There are no pines on this face. Immediately the summit is reached, at a height of about 7,000 feet, one enters a fine open forest of *Pinus arizonica* with species of *Arctostaphylos*, *Quercus emoryi* and *Ceanothus Fendleri* as undergrowth. The trail winds through this forest round the valley sides for a considerable way, and magnificent distant views of the lower slopes and the desert are obtained. In the damper shaded valleys deciduous trees and shrubs like *Acer interior* (of the Negundo type) and *Alnus acuminata* occur. At about 7,800 feet the manzanitas, *Arbutus* and *Quercus emoryi* disappear and isolated trees of *Pinus strobusiformis* are met with. In the pine-wood at this level a whole set of herbaceous "montane" plants are found: the beautiful *Aquilegia chrysanthia* and *Lobelia Grewiana* by damp stream-sides, *Potentilla Thurberi*, *Heuchera rubescens*, *Oreolirion (Sisyrinchium) arizonicum*, *Gilia Thurberi*, with *Pteridium aquilinum* and *Achillea Millefolium*. In a north-facing canyon a thick stand of Douglas spruce with *Abies concolor* and fine trees of *Acer grandidentatum* with deciduous undergrowth indicate a still higher zone. Beyond, a flat-topped ridge, more than 8,000 feet above the sea, is traversed, with fine forest of yellow pine; and a short but steep descent brings the trail to

Marshall Gulch, the last camping ground. The nights in Marshall Gulch at this time of year are very cold, a thick layer of ice being formed on the water left overnight in pails. Marshall Gulch is occupied by Douglas spruce wood; associated with the dominant are *Abies concolor* and *Pinus strobiformis*, with *Acer grandidentatum*, *Populus tremuloides*, *Alnus acuminata*, *Quercus submollis*. A rich "montane" ground-flora occurs in the wood, a majority of the forms belonging to genera also occurring in northern Europe, such as *Rubus*, *Ribes*, *Cornus*, *Silene*, *Aquilegia*, *Aconitum*, *Actaea*, *Viola*, *Fragaria*, *Agrimonia*, *Lathyrus*, *Vicia*, *Trifolium*, *Heracleum*, *Valeriana*, *Mimulus*, *Galium*, *Erigeron*, with a few European species —*Pteridium aquilinum*, *Cystopteris fragilis*, *Pyrola minor*.

September 25th was devoted to the ascent of Mount Lemmon and a short circuit through the woods on the north side of the main range. The southern slopes of Mount Lemmon, from 8,000 to 9,000 feet, much more exposed to the sun than the valleys like Marshall Gulch, are covered with a rather sparse wood of *Pinus arizonica*, with *Quercus reticulata*, *Q. hypoleuca* (evergreen), *Q. Gambelii* (a deciduous but leathery-leaved form), and *Ceanothus Fendleri*. This vegetation goes right up to the summit (just over 9,000 feet) and is very little affected by wind. On the steepest faces the pines are few and the ground is mostly occupied by oak scrub. The view from the summit of Mount Lemmon is very extensive, reaching to the Sonoran mountains in Mexico to the south, and the northern Arizona mountains leading up to the Great Colorado Plateau on the north. On the north face there is good forest of *Pseudotsuga* and *Abies concolor*, with many of the same species as in Marshall Gulch.

On September 26th the return journey was made as far as the Bear Canyon camp, where it was still very cold at night, though the thermometer did not actually go below freezing point. By mid-day on the 27th we were back on the baking desert plains with shade-temperatures of over 100°F., returning to Tucson by automobile from the foot of the mountains.

The Santa Catalina trip was in many respects the most enjoyable part of the whole tour. The restful days of riding slowly through the great pine forests in perfect weather, the glorious, ever-changing views, the fine zonation of the vegetation, the abundance of interesting plants, and the many talks round the camp fire at night with our kind and thoughtful hosts from the Desert Laboratory—these things combined to make the week's camping trip an experience impossible to forget.

NEW MEXICO AND KANSAS.

September 28th and 29th were spent in and around Tucson, and on the afternoon of the second day we rejoined the main party on their return from the Grand Canyon and travelled with them to El Paso (Texas) 300 miles to the east, on the Mexican border, where we arrived on the morning of September 30th. Here we had a few hours to spare, and walked across the dry bed of the Rio Grande into the Mexican town of Ciudad Juarez, soon afterwards the scene of much bloody fighting. The bulk of the party then continued their journey south-eastwards to New Orleans, while the writer travelled north-eastwards to Chicago by the Rock Island line, traversing the states of New Mexico, Kansas and Illinois. From El Paso (3,700 feet) to Alamogordo (4,312 feet) the country is good semi-desert, the average height of the undershrubs not being more than eighteen inches. *Yucca* and *Agave* are locally abundant, and various grasses and other herbs occur—thickly in places—among the woody plants, though at this time of year they are mostly dried up. *Gutierrezia* and an *Artemisia* were also abundant. About Alamogordo the shrubs become taller and a fine range of mountains with forest on the higher slopes is approached, and before Carrizozo (5,438 feet) is reached the grasses have become practically continuous and the woody plants, except locally, have almost disappeared. The "Great Plains" region is entered. A species of *Yucca* is still abundant locally. The hills near the railroad are scrub-covered to their base, with grassy mesas in front. The line steadily climbs, and near Largo (6,000 feet) Juniper scrub mixed with *Yucca*, *Dasyliion* and a much branched *cylindropuntia* is scattered thickly in the grassland. Presently a Pignon pine comes in, mixed with the scrub and forming a dwarf wood. This apparently extends over the summit of the divide, which is crossed near Corona at 6,666 feet, but darkness prevented further survey of the vegetation.

On the morning of October 1st we entered the south-western corner of Kansas, still in the Great Plains type of country. During the day as we travelled north eastwards through the state this gradually changed to the Prairie type. It is noticeable that here, just as further north in Nebraska, while the vegetation of the Great Plains is still almost entirely in a natural state, no natural prairie could be seen from the train, the land being almost entirely arable—now in stubble. Trees began to show much more

luxuriant growth, and around Herington and beyond natural river-bottom woods began to appear, the cultivation stopping, again as in eastern Nebraska, with the limits of the original prairie. Around Topeka woods—largely of oak—began to appear on the hills, and further on thick woods covered the hills, the lowlands being black soil prairie, all under crops. Along this diagonal section across the state of Kansas no considerable hills are anywhere encountered, and the country is all flat or gently rolling plains with occasional low ranges. Kansas City was reached after dark, and early in the morning we crossed the Mississippi and were soon in the familiar country of the state of Illinois, reaching Chicago before noon.

AUTUMN COLOURS.

After a few days spent in Chicago the writer travelled to Boston and thence sailed for England. In the New England and adjoining states—especially in the Berkshire Hills (New York)—the autumn colours were in their full glory. The greater richness and variety of the autumn colouring seems to be due to the much greater variety of trees and shrubs as compared with north-western Europe, rather than to climatic differences. Thus there is a greater absolute number of species which show beautiful and conspicuous colours, such as crimson, rose-red and orange, than is the case in our own much poorer woody flora. The autumn in Illinois, Indiana, and in New York and the New England states was, at least in 1913, distinctly earlier than in England. The trees at Chicago had lost more leaves at the beginning of October than our own past the middle of the month, when the landscape and gardens still full of flowers showed almost a late summer aspect. There must indeed have been three weeks or even a month's difference between the seasons. This may have been partly due to the very hot American summer and the cool British summer of 1913. The spring at Boston in mid-May was certainly no more or even less advanced than that of central England at the end of April. Both these things are no doubt mainly due to the continental as opposed to our insular climate.

I cannot close this rather sketchy account of the American I. P. E. of 1913, without again trying to express the deep indebtedness of all the members of the party to our American hosts, who, one and all, did everything in their power to make our visit pleasant and profitable. Certainly no member of the international party will ever

forget the overwhelming impressions we received of American landscapes and vegetation, designed truly on the grand scale, or of unrestrained American hospitality. Apart from these the most vivid impression I personally obtained was of the earnestness and single-mindedness of American science. In the vast field of ecology America has secured a commanding position and from the energy and spirit with which the subject is being pursued by very numerous workers and in its most varied aspects, there can be little doubt that her present pre-eminence in this branch of biology—one of the most promising of all modern developments—will be maintained.

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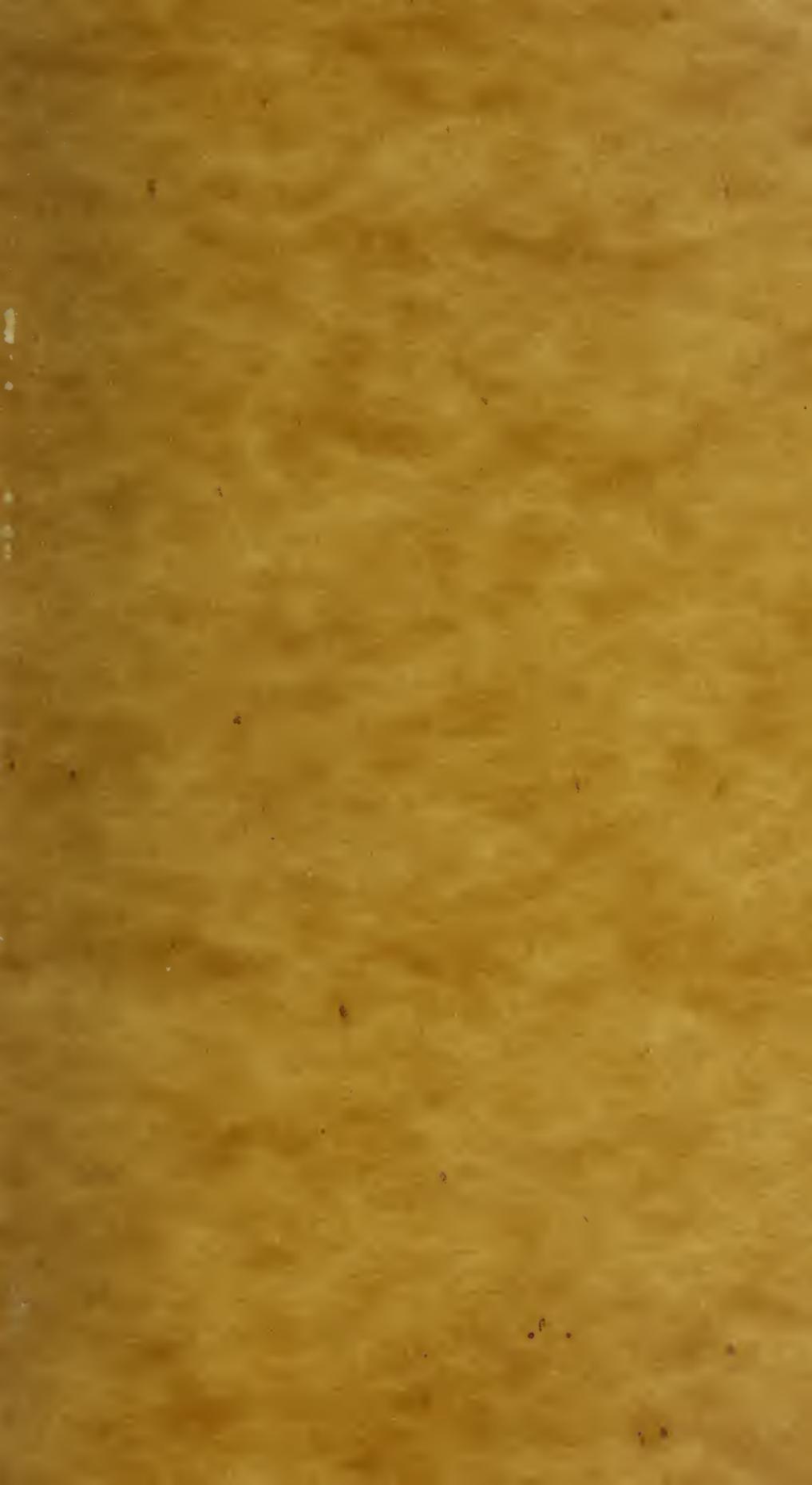
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